Harappa Excavations 1986-1990

A Multidisciplinary Approach to Third Millennium Urbanism

Edited by Richard H. Meadow

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in Harappan Phase Cemetery (see Figure 13.18).

Contents

List of Contributors .... *iv*
List of Figures .... *v*
List of Tables .... *vii*
Preface
Richard H. Meadow .... *ix*

1. Project Director's Introduction
George F. Dales 1

2. A Short History of Archaeological Discovery at Harappa
Gregory L. Possehl 5

3. Pedology and Late Quaternary Environments Surrounding Harappa: A Review and Synthesis
Ronald Amundson and Elise Pendall 13

4. Urban Process in the Indus Tradition: A Preliminary Model from Harappa
Jonathan Mark Kenoyer 29

5. Some Specialized Ceramic Studies at Harappa
George F. Dales 61

6. Patterns of Technology and the Organization of Production at Harappa
Rita P. Wright 71

7. Faunal Remains and Urbanism at Harappa
Richard H. Meadow 89

8. Fish Resources in an Early Urban Context at Harappa
William R. Belcher 107

9. Urban Palaeoethnobotany at Harappa
Heather Margaret-Louise Miller 121

10. Complementary Approaches to Late Harappan Subsistence: An Example from Oriyo Timbo
Seetha N. Reddy 127

11. Biological Adaptations and Affinities of Bronze Age Harappans
Brian E. Hemphill, John R. Lukacs, and K.A.R. Kennedy 137

12. Personnel of the Harappa Project 1986-1990
.... 183

13. Summaries of Five Seasons of Research at Harappa (District Sahiwal, Punjab, Pakistan) 1986-1990
George F. Dales, Jonathan Mark Kenoyer, and the staff of the Harappa Project 185

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Illustrations

1.1. Harappa 1990 site plan showing extent of excavations. 2
2.1. "Ruins of Harapâ" redrawn after Cunningham (1875). 7
2.2. Plan of Harappa from Vats (1940). 9
3.1. Generalized geomorphological map of Pakistan. 15
3.2. Topographic cross-section of the river Ravi. 16
3.3. A reconnaissance geomorphological map of a section of the river Ravi. 17
3.4. Soil map of the region immediately surrounding Harappa. 19
3.5. Carbon isotopic composition of carbonate in nodule layers and in soil. 23
3.6. Carbon isotopic compositions of inner nodule carbonate. 24
3.7. Oxygen isotopic composition of carbonate in nodule layers and in soil. 24
4.1. Map showing major sites of the Indus Tradition, Harappan Phase. 30
4.2. Harappa 1990 site plan showing extent of excavations. 31
4.3. Harappa figurines and tokens. 33
4.4. Plan of Harappa Mound AB; redrawn from Wheeler (1947). 36
4.5. Detail of section through the mud-brick rampart, Harappa Mound AB. 37
4.6. Harappa: Reconstructed E-W section through Mounds AB and E. 39
4.7. Harappa: Map showing model for extent of occupation in different periods. 39
4.8a. Harappa radiocarbon determinations: arranged stratigraphically. 41
4.8b. Harappa radiocarbon determinations on material from hearths. 42
4.9. Harappa 1990: Plan of NW corner of Mound E. 45
4.10. Harappa 1988: Section of trench cut through NW slope of Mound E. 46
4.11. Harappa 1990: Section of trench in Area C on the S side of Mound E. 48
4.12. Harappa 1990: Plan of cart tracks in natural sediment, S side of Mound E. 49
4.13. Harappa 1990: Plan of excavated areas on S slope of Mound E. 51
4.14. Harappa 1990: Sections on north side of mud-brick walls, S slope, Mound E. 52
4.15. Harappa 1990: Plan of peripheral wall and gateway, S slope, Mound E. 53
4.16. Harappa 1990: Plan of structure and upper street levels, S slope, Mound E. 54
4.17. Harappa 1988: Painted pottery motifs from the Period 3 cemetery. 55
5.1. Harappan phase cemetery: selection of burial pottery. 63
5.2. Harappan phase cemetery: jar with intentional coating(s) of clay. 63
5.3. Early Harappan (Period 1/2) ceramics from Harappa, Mound E, NW corner. 64
5.4. Transitional (Period 2) pot from Harappa, Mound E, NW corner. 65
5.5. Harappan phase female figurine from Harappa 66
5.6. Harappan phase female figurine from Harappa. 67
5.7. Figurines from western Asia. 67
6.1. Map of Harappa. 77
6.2. Map of NW corner of Harappa Mound E. 79
6.3. Cylindrical jars produced "on the hump." 80
6.4. Ledge-shouldered jars and the production process. 81
6.5. Cooking and fluted pots and the production process. 81
6.6. Large storage jars and the production process. 82
7.1. Difference of logarithms diagram for bone dimensions from different sites. 91
7.2. Diagram showing percentage of measured specimens larger than standard. 92
7.3. Difference of logarithms diagram for cattle bones from Harappa. 95
7.4. Difference of logarithms diagram for cattle bones from Nausharo. 95
7.5. Difference of logarithms diagram for goats and sheep bones from Harappa. 96
7.6. Difference of logarithms diagram for goats and sheep bones from Nausharo. 96
7.7. Harappa 1990: Section of trench in Area C on the S side of Mound E. 98
7.8. Log plot of density and mean weight of mammal bones from street in Area C. 99
8.1. Map showing locations of major sites of the Indus Civilization. 108
8.2. Harappa 1990: Plan of structure and upper street levels, S slope, Mound E. 109
8.3. Fresh fish trade flow chart. 110
8.4. Dried fish trade flow chart. 111
8.5. Harappa fish remains 1990. 113
8.6. Fish species variation in loci on S side of Mound E. 115
8.7. Fish bone element representation in loci on S side of Mound E. 115
8.8. Fish species variation in street. 116

8.9. Sherd, fishhook, and tokens from Harappa. 118
9.1. Questions for urban palaeoethnobotany. 122
9.2. Basic crop processing stages. 122
10.1. Oriyo Timbo (1989-90): total identified carbonized seeds by strata. 129
10.2. Oriyo Timbo (1989-90): frequency ratios of millets, legumes, and weeds. 130
10.3. Oriyo Timbo (1989-90): densities of seeds/10 liters. 130
10.4. Hypothesized crop processing product & by-product compositions. 131
10.5. A preliminary predictive model for millet crop processing stages. 132
10.6. An animal feeding model. 133
11.1. Location of the Harappan phase cemetery within the site of Harappa. 140
11.2. Tooth size among South Asians. 146
11.3. Tooth size reduction over time. 146
11.4. Dental pathologies by individual count by sex at Harappa. 148
11.5. Dental pathologies in the prehistoric Indus Valley by individual count. 149
11.6. Caries frequency among prehistoric South Asians. 150
11.7. Cluster analysis of craniometric variation among prehistoric peoples by sex. 151
11.8. Ordination of principal component scores from craniometric variation by sex. 153
11.9. Cluster analysis of craniometric variation among South Asians. 154
11.10. Two and three dimensional ordination of principal component scores. 156
11.11. Cluster analysis of craniometric variation among all groups. 158
11.12. Ordination of principal component scores from craniometric variation. 159
11.13. Cluster analysis of dental non-metric trait variation among South Asians. 160
11.14. Multidimensionally scaled ordination of dental non-metric trait variation. 163
11.15. Ordination of principal component scores from dental non-metric traits. 165
11.16. Cluster analysis of cranial non-metric trait variation among all groups. 165
11.17. Multidimensionally scaled ordination of cranial non-metric trait variation. 167
11.18. Ordination of principal component scores from cranial non-metric trait variation. 170
13.1. Harappa 1990 site plan showing extent of excavations. 186
13.2. Harappa 1986 site plan showing location of test pits and benchmarks. 188
13.3. Harappa expedition house, constructed in 1986. 192
13.4. Conservation and research laboratory in Harappa expedition house. 192
13.5. Harappa 1987 cemetery excavations: contour map of unexcavated surface. 193
13.6. Harappa 1987 cemetery excavations: location of test pits and excavated area. 194
13.7. Harappa 1987 cemetery excavations: plan of upper levels. 196
13.8. Harappa 1987 cemetery excavations: plan of lower levels. 197
13.9. Harappa 1987 cemetery excavations: N-S sections. 198
13.10. Harappa 1987 cemetery excavations: Burials 134a and 148a. 199
13.11. Harappa 1987 cemetery excavations: Burial 147a. 200
13.12. Harappa 1987 cemetery excavations: Burial 127a. 201
13.13. Harappa 1987: steatite stamp seal and faience token. 203
13.14. Harappa 1987 animal figurines. 204
13.15. Harappa 1987 human figurines. 205
13.16. Harappa 1987-1988 cemetery excavations: plan of upper levels. 207
13.17. Harappa 1987-1988 cemetery excavations: plan of lower levels. 208
13.18. Harappa 1988 cemetery excavations: Burials 196a, 194a, and 194b. 209
13.19. Harappa 1988 cemetery excavations: burials in fields west of area R37. 211
13.20. Harappa 1988: Mound AB, Operation 2: plan of excavations. 214
13.21. Harappa 1988: Mound AB, Operation 2: section through well. 215
13.22. Harappa 1988: Mound E, NW slope: east-west section at edge of mound. 216
13.23. Harappa 1988: Mound E, NW slope: N-S section showing platforms. 217
13.24. Harappa 1988: Mound E, NW slope: plan view of walls and revetment. 218
13.25. Harappa 1988: Mound E, NW slope: plan view of walls and revetment. 219
13.26. Harappa 1988: Mound E, NW slope: east-west section at edge of mound. 220
13.27. Harappa 1988: Mound E, NW slope above kiln: N-S section. 222
13.28. Harappa 1988: Mound E, NW slope: plan of kiln area. 223
13.29. Harappa 1988: top of Mound E, NW corner: plan of Harappan structures. 224
13.30. Harappa 1988: top of Mound E, NW corner: plan of Harappan structures. 225
13.31. Harappa 1988: Bull seal from S edge of Mound E. 226
13.32. Harappa 1988: Early Harappan phase figurines from NW corner of Mound E. 231
13.33. Harappa 1989: Mound E, NW corner: plan of architecture. 232

13.34. Harappa 1989: Mound E, NW corner: section through mound. 233
13.35. Harappa 1989: Mound E, NW corner: section through perimeter walls. 234
13.36. Flow chart of vessel forms created for classification of Mohenjo-daro pottery 237
13.37. Harappa 1990: Mound E, NW corner: plan of architecture. 241
13.38. Harappa 1990: Mound E, NW corner: sections through Period 2 and 3 deposits. 242
13.39. Harappa 1990: Mound E, S slope: general plan of area excavated. 244
13.40. Harappa 1990: Mound E, S slope, Area C: plan view. 245
13.41. Harappa 1990: Mound E, S slope, Area C: plan of lowest street level. 246
13.42. Harappa 1990: Mound E, S slope, Area A: section of structures and drains. 247
13.43. Harappa 1990: Mound E, S slope, Area A: plan views of drains. 248
13.44. Harappa 1990: Objects with script from Mound E, S slope. 249
13.45. Harappa 1990: Mound E, S slope, Area C: section of street. 250
13.46. Harappa 1990: Objects with script from Mound E, S slope, Area C. 252
13.47. Harappa 1990: Mound E, S slope, Area F: plan of peripheral wall & gateway. 253
13.48. Harappa 1990: Mound E, S slope, Area F: plan of perimeter wall excavation. 254
13.49. Harappa 1990: Mound E, S slope, Area F: section through perimeter walls. 255
13.50. Harappa 1990: Mound E, S slope, Area F: section of perimeter wall at gateway. 257
13.51. Harappa 1990: Mound E, S slope, Area F: section across gateway. 258
13.52. Harappa 1990: Mound E, S slope, Area F: sections of perimeter wall. 259
13.53. Harappa 1990: Objects with script from Mound E, S slope. 260

Tables

2.1. Number of excavation seasons of selected sites of the Harappan Tradition. 6
3.1. Calculated slopes of some landforms in the vicinity of Harappa. 15
3.2. Field descriptions of typifying soils of mapping units. 20
3.3. The relative and estimated absolute ages of the mapping units. 21
4.1. General stratigraphy adapted from Vats (1940). 32
4.2. Harappa 1991: preliminary periodization. 40
4.3. Harappa dates arranged stratigraphically from latest to earliest. 43
4.4. Elevations of "natural soil" found in excavation areas. 44
7.1. Standard dimensions used to compile Figures 7.1-7.6 and Table 7.2. 93
7.2. Statistics used to compile Figures 7.1 & 7.2. 94
7.3. Harappa Mound E South, Area C, Street NS2355. 99
7.4. Counts of mammal bone from Harappa Mound E South, Area C, Street NS2355. 100
7.5. Standardized counts of fauna from Harappa Mound E South, Street NS2355. 101
11.1. Sex distribution of the Harappan phase cemetery samples. 141
11.2. Age distribution of the Harappan phase R37C sample. 141
11.3. Harappan phase R37 dental sample by burial context and by sex. 141
11.4. Dental non-metric sample sizes and sources. 142
11.5. Cranial non-metric sample sizes and sources. 143
11.6. Craniometric sample sizes and sources. 145
11.7. Crown diameters and areas of permanent teeth from Harappa (R37C). 145
11.8. Prevalences of dental diseases at Harappa (R37C) by individual count. 147
11.9. Prevalences of dental diseases at Harappa (R37C) by tooth count. 148
11.10. Analysis of variance of cranial measurements of prehistoric peoples by sex. 151
11.11. Principal components analysis of cranial measurements of males & females. 152
11.12. Analysis of variance of cranial measurements of South Asians by sex. 154
11.13. Group mean parameters for cranial measurements of all groups. 155
11.14. Principal components analysis of craniometric variation among South Asians. 156
11.15. Analysis of variance of cranial measurements among all groups by sex. 157
11.16. Principal components analysis of craniometric variation among all groups. 158
11.17. Frequencies of dental non-metric traits among prehistoric South Asians. 161
11.18. Contingency analysis of dental non-metric traits of prehistoric South Asians. 162
11.19. Mean measure of distance scores derived from dental non-metric variation. 162
11.20. Principal components analysis of dental non-metric variation. 164
11.21. Frequencies of cranial non-metric traits among all groups. 166
11.22. Contingency chi-square analysis of cranial non-metric traits among all groups. 167
11.23. Mean measure of distance scores derived from cranial non-metric variation. 168
11.24. Principal components analysis of cranial non-metric variation among all groups. 169

Preface

Interim or preliminary reports in archaeology occupy a particular place. They reflect current thinking about a project—what the excavator(s) or analyst(s) believe has been accomplished and what they think remains to be done. In the short term, they serve as a means for specialist colleagues to judge accomplishments and identify shortcomings. For the long term, however, do they have any lasting value?

Interim reports are important historical documents. And with increasing specialization in the analysis of archaeological remains and materials, they may be the only place where a project is presented as a whole. They often reflect how work developed, why certain decisions were made about what to do and what to do next, and how understandings grew and changed over the course of fieldwork. They have an immediacy that final reports lack and thus are an integral part of the documentation of a site or project. If one wishes to understand the details of Sir Leonard Woolley's excavations at Ur in Mesopotamia, one must consult not only the final *Ur Excavations* volumes 2–10 (London and Philadelphia, 1934–1976), but the preliminary reports published during the years of excavation between 1922 and 1934 in the *Antiquaries Journal* (London) and the *Museum Bulletin* (Philadelphia). Indeed, for nearly half a century those articles provided the principal source of information on periods at the site that did not come to be finally published until the 1970s.

The situation is no different for Harappa. M.S. Vats published in 1940 a "final report" on the work carried out at the site between 1920 and 1934 (contemporary with the work at Ur). Excavations carried out since then, if reported at all, are described only in preliminary reports (see Possehl, Chapter 2 in this volume). Vats and Sahni before him also published interim statements in the *Annual Reports of the Archaeological Survey of India* that are still of value today especially to those of us working at the site.

We, therefore, do not apologize to the reader that what lies before her or him is an interim report. Indeed it is more "interim" than we had expected. When we planned the symposium "The Archaeology of Urbanism at Harappa, Pakistan" for the 1991 meetings of the Society for American Archaeology, we thought we would have just completed our sixth season at Harappa. Instead international politics intervened, and we now hope that the sixth season will take place in the first quarter of 1992. Thus many of the articles in this volume are more preliminary than they would have been if we had been able to carry out the study of pottery, small finds, and paleobiological materials that had been planned for 1991. While all contributions were affected, those of George Dales (Ch. 5) and Rita Wright (Ch. 6) on the ceramics and Heather Miller (Ch. 9) on the paleoethnobotanical remains were more so than the others. Thus these authors have defined an orientation and provided a methodological or theoretical foundation for future work based on what had been accomplished to date. In contrast, the papers of the biological anthropologists (Hemphill, Lukacs, and Kennedy, Ch. 11) and the soil scientists (Amundson and Pendall, Ch. 3) are more finished statements, based on data sets that have

been in hand since the end of the third season. The articles of Kenoyer (Ch. 4), Meadow (Ch. 7), and Belcher (Ch. 8) fall between these extremes. Finally the contribution of Reddy (Ch. 10), although not dealing directly with Harappa, is included as her work is closely related to that of Miller (Ch. 9) who cites it on a number of occasions.

Chapters 12 and 13 are different than those that come before. Chapter 12 comprises a list of personnel of the Harappa project. The fact that it appears as a chapter in its own right is testimony to the importance of the contributions made by the individual participants. Not listed are the more than one hundred individual Pakistani workers without whose assistance the project would have been impossible. By the end of the fifth season many of these men had become more skilled at their individual tasks than any of their supervisors and, indeed, some had become supervisors themselves. On behalf of all of us, I wish here to express special thanks and appreciation to these our fellow archaeologists.

Chapter 13 is a redaction of the yearly reports submitted to the Department of Archaeology, Government of Pakistan, within six months after each field season. Versions that are more completely illustrated with figures depicting small finds and pottery can be found in issues of *Pakistan Archaeology* starting with volume 24 (1989). We thought, however, that it would be useful if the reports, in edited form, were all included here so that the interested reader could follow the course of the project over its life of five seasons to date. Also, these reports contain information that is not included in any of the other chapters. Thus the volume as a whole provides the reader with a comprehensive overview of what was accomplished from 1986 to 1990 by the University of California-Berkeley /Department of Archaeology Project at Harappa.

In editing this volume, I attempted to standardize some of the terminology. In particular, "Early Harappa phase," "Harappan phase," and "Late Harappa phase" are used throughout the book in the sense defined by Jim Shaffer in his contribution to *Chronologies in Old World Archaeology*, 3rd edition. Terms such as "pre-Harappan," "mature Harappan," "urban Harappan," and "post-urban Harappan" are not used except in historical context or where unavoidable.

George Dales, in Chapter 1, has provided acknowledgements to persons and institutions supporting the work at Harappa. Here I wish to credit individuals assisting in the publication of this volume. All the authors were so incredibly prompt in providing their contributions and sending modifications in line with editorial comment that my article came to be the last to be completed. Mark Kenoyer helped in the initial stages of the editing and by comments at other points in the process. He also is the source of nearly all of the plans and sections, which is a great work in itself. Jay Knight and Carol Bracewell are delightful people with whom to work when publishing a manuscript quickly and in style; they also provided invaluable editorial assistance with Chapter 13.

Common to all contributions in this volume is an understanding that Harappa is an urban site and thus a complicated object of study requiring a multidisciplinary approach over a long period of time. This is neither a straightforward nor inexpensive task and is made the more difficult at Harappa by the brick-robbing that took place in the 19th century. Greatly to the credit of George Dales is that he planned from the beginning for a long-term project, assembled the required staff, and constructed the facilities necessary to house them in relative comfort and provide for them a well-designed and properly equipped place to work. This has promoted the general health and sanity of project personnel and permitted appropriate conservation techniques to be applied to finds that otherwise would have disintegrated because of high salt content. Indeed, George's insistence on staffing a well-equipped conservation laboratory with well-trained staff has made it a model field installation. His initial focus on cemetery excavations and the inclusion of a quartet of physical anthropologists will soon yield a remarkable pair of final volumes that promises to set a new standard for the study of human remains. In sum, the support and encouragement of the interests of all members of the staff by both George and Barbara Dales have been remarkable.

As far as this volume is concerned, with great generosity George Dales encouraged me to take on the task of editing it. He not only provided two contributions (Ch. 1 and Ch. 5) but prepared Chapter 13 in its initial form. He supplied many of the object illustrations (including the cover art) and all of the photographs. His most important contribution, however, continues to be the encouragement and assistance he provides for us to carry on with our studies of Harappan archaeology and of the archaeology of Harappa.

Richard H. Meadow
Cambridge, 30 October 1991

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Cover art: Bowl on Stand H88-1002/192-17 associated with Burial 194a
in Harappan Phase Cemetery (see Figure 13.18).

1

Project Director's Introduction

George F. Dales
University of California-Berkeley

The urban site of Harappa (District Sahiwal, Punjab, Pakistan–Figure 1.1) has a special place in Old World archaeology. From there, in the mid-19th century, first came artifacts of an unknown ancient culture that were to attract the attention of western scholars. Square stone stamp seals inscribed with a still enigmatic script provided the first evidence for the existence of what we know today to be South Asia's earliest urban society, sometimes called the "Harappan Civilization" after the site itself.

Not until the early 1920s, however, were large-scale excavations at Harappa initiated by the Archaeological Survey of India. (See Chapter 2 in this volume by Gregory Possehl for an outline of the history of excavations at Harappa.) Concurrently, excavations were begun some 400 miles to the southwest at Mohenjo-daro. Similarities in artifacts, inscriptions, and architecture immediately made it clear that both Harappa and Mohenjo-daro were major centers of an unexpectedly early urban culture centered in the Indus Valley. Extensive excavations through the 1920s and into 1930s at both sites, together with subsequent discoveries and excavations at smaller sites in what are now Pakistan, western India, and even Afghanistan, have revealed a vast and unique South Asian counterpart to the better known ancient cultures of the Near East and Egypt.

Since 1986, the University of California at Berkeley has been participating with Pakistan's Department of Archaeology in a multi-disciplinary research project at Harappa. In this volume we present an overview of some of the directions in which our research is taking us together with some of the most significant results of the first five years of the project. I wish to thank those of our team who were able to present papers at the Society for American Archaeology symposium in New Orleans (April 27, 1991) and to revise them for inclusion here. Also, I want to thank Gregory Possehl and Jim G. Shaffer for acting as discussants in the New Orleans session that was titled "The Archaeology of Urbanism at Harappa, Pakistan." We all extend thanks to Richard Meadow who served as organizer of the symposium and editor of this volume.

The long range objectives of the Harappa project focus on developing a better understanding of the cultural, economic, and social history of Harappa as a discrete urban phenomenon as well as elucidating its role in the development and life of the Indus Civilization as a whole. The physical nature of Harappa provides unusual opportunities to investigate these questions, opportunities that are not available, for example, at Mohenjo-daro where the present water table is too high to allow excavations in the lowest and earliest levels. An even more important feature of Harappa is that the site comprises three successive cultural phases: a "pre-Indus" or "Early Harappan" phase having affinities with Kot Diji, Jalilpur, and other late fourth and early third millennium sites in northern Pakistan; the "mature Indus" or "urban Indus" or "Harappan" phase as first

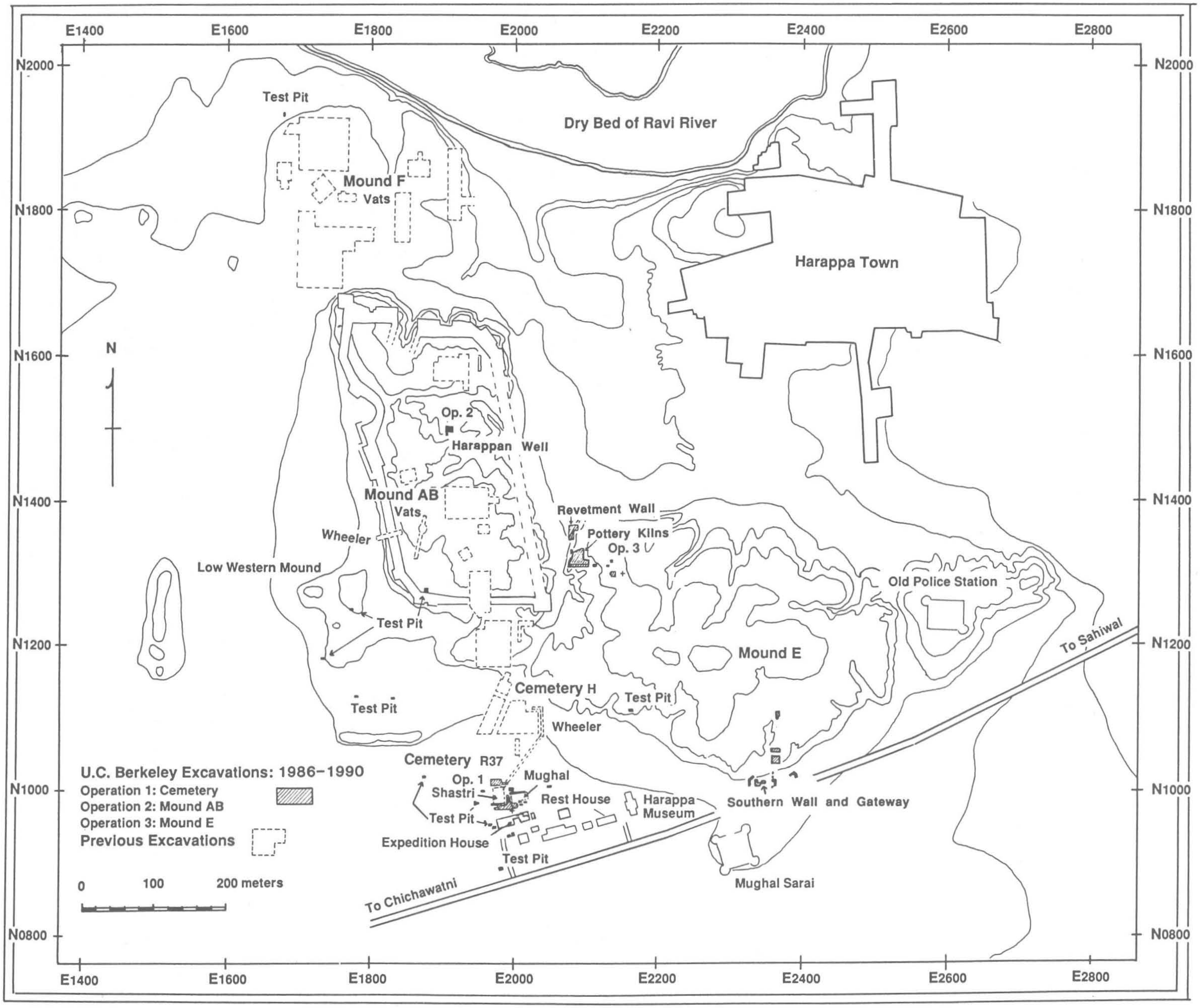

Figure 1.1: Harappa 1990 site plan showing extent of excavations.

defined by the early excavations at Harappa and Mohenjo-daro; and a "post-Indus" or "Late Harappan" phase defined by the distinctive pottery found first in Cemetery H at Harappa.

Our excavations have demonstrated the research potentials as well as some of the preservation problems offered by Harappa. We have discovered at least one main focus of occupation of the Early phase, and although it was founded on natural sediment, there is no ground water problem. Intact architectural remains of Early Harappan (our Period 1) have been exposed followed by remains of what appears to be a transitional phase (Period 2) leading into the urban Harappan phase (Period 3). The potentials for investigating the origins and early development of this major urban settlement and its role within the Indus Civilization are boundless, requiring only imaginative field strategies and adequate funding.

At the later end of the time scale, however, Harappa does present some problems. During the mid-19th century, Harappa (along with other ancient sites) was used as a source of fired bricks for ballast for the construction of the railway bed between Multan and Lahore. The uppermost brick architecture was dismantled and the edges of the mounds were perforated with tunnels that followed the lines of fired brick walls. The result is that there are virtually no structures of the Late Harappan phase (Period 5), and little architecture of the latest Harappan phase (Period 4) remains intact. The subsequent collapse of the tunnels, the burrowing of animals, and erosion from the annual rains make the prospects slim for discovering significant information relating to the end of the Harappan phase and to the relationships between the Harappan and Late Harappan (Cemetery H) occupations.

But these drawbacks are far offset by the positive features of the site. The papers presented in this volume testify to the fact that after just five seasons of work at this enormous site, we have made significant new discoveries concerning the structural and cultural development of the city, the history of technologies and crafts, the knowledge and exploitation of the natural environment, and the socio-economic and cultural life of the city.

Two important aspects of the project, however, are not directly reflected in this volume. The first is conservation. The expedition house we constructed in 1986 includes a large field conservation laboratory equipped and supplied following the advice of personnel from the Smithsonian's Conservation Analytical Laboratory who have participated in operating the lab during the field seasons. In the laboratory, desalinization, cleaning, and consolidating of excavated items have been given first priority, although considerable attention has also been devoted to assisting the site curator in matters relating to the conservation of the site and of specific artifacts in the collection of the Harappa Museum. In addition, our conservators have assisted in the training of Pakistani personnel from the Department of Archaeology and from the Lahore Museum.

The second aspect of the project not directly covered by the papers in this volume is the training program we have offered for Pakistani graduate students, junior officers in the Department of Archaeology, and staff from the Lahore Museum. Month-long intensive courses in basic field and laboratory techniques were offered almost every season. In addition to providing the participants with an opportunity to learn something of our way of doing archaeology, the training program has allowed us the pleasure of interacting with a broader spectrum of the Pakistani scholarly and archaeological community than would have been possible only in our own research program.

The principal medium for initial publication of the results of each season's work is *Pakistan Archaeology*, the journal of the Department of Archaeology, Government of Pakistan. For the convenience of readers of this volume, however, we have abstracted these preliminary reports and included them here as Chapter 13. Final publication of various aspects of our work is well underway. The first report to go to press (in late 1991 or early 1992) will be that concerned with the excavations in the Harappan phase cemetery (R37); it comprises the reports of the physical anthropologists together with basic grave lot descriptions. This will be followed by a volume describing in detail the artifacts from the cemetery. As work in other areas is completed, additional publications will be compiled.

Acknowledgements are due many persons and institutions in this country, Pakistan, and Europe. We express thanks to Pakistan's Department of Archaeology, to its Director during the initial negotiations for the license—Mohammad Ishtiaq Khan— and to its current director—Dr. Ahmed Nabi Khan. We appreciate the cooperative and supportive spirit that has prevailed since the start of the project in 1986. We are grateful to the officers of the Ministry of Information, Sports and Tourism who approved the initial license and its renewal in 1989; to Dr. Mohammad Rafique Mughal, Director of Archaeology, Northern Circle, who has been directly responsible for overseeing the project; to the curators of the Harappa Museum and to the various Field Officers of the Department of Archaeology who have worked with us in the field (their names are given in Chapter 12); to Dr. Saifur Rahman Dar, Director, Lahore Museum, who deputed three of his officers to

work with us at various times in the field—Mr. Waseem Ahmad, Mr. Shahbaz Khan, and Mr. Tariq Masud; to the many persons in the American Embassy in Islamabad and the Consulate in Karachi—especially those in USIS—who provided support, encouragement and lecture opportunities; to Donna Strahan, then of Smithsonian's Conservation Analytic Laboratory (and now of the Walters Art Gallery, Baltimore) who helped plan, equip and operationalize our field lab during the first three seasons; to the Museum of Fine Arts, Boston, for sending Margaret Leveque to work as Assistant Conservator during the 1987 season; and to the Smithsonian's CAL for sending Harriet Beaubien to act as Conservator for the 1989 and 1990 seasons.

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Finally, I want to express my personal thanks to the members of the Harappa staff who have worked so diligently and faithfully to make the project a success. This has been the most cooperative, skilled and companionable team that I have ever worked with in the field—professors, graduate students and specialists alike—and I find it difficult to fully express my appreciation to them all for their support and assistance during some often difficult times.

Harappa Excavations 1986-1990

A Multidisciplinary Approach to Third Millennium Urbanism

Edited by Richard H. Meadow

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Cover art: Bowl on Stand H88-1002/192-17 associated with Burial 194a in Harappan Phase Cemetery (see Figure 13.18).

2

A Short History of Archaeological Discovery at Harappa

Gregory L. Possehl
The University Museum, University of Pennsylvania

Since the first publication of material in 1872, the site of Harappa has provided a principal focus for protohistoric archaeological investigations in the Punjab region of northwestern South Asia. The current University of California, Berkeley, project is here put into the context of earlier work at the site and into the context of the history of archaeology in the Greater Indus Valley as a whole.

Harappa has been the most frequently investigated of any of the ancient settlements of the Harappan cultural tradition. Since Sir Alexander Cunningham first excavated at the site in 1872-1873, there have been not fewer than 26 "seasons" of work at the site. This does not include the "digging" done by Deputy Superintendent of Police T.A. O'Connor in 1886. I have placed "seasons" in quotation marks since I am using this term to cover relatively short but important periods of work at sites as well as sustained campaigns lasting several weeks. In fact, if one considers only number of seasons and not extent of excavation, there appears to have been considerably more work at Harappa than at Mohenjo-daro, the next site in this regard. Table 2.1 makes this point.

Discovery of the ancient cities of the Indus was based on excavations during the 1920s at Harappa and Mohenjo-daro (Possehl 1982), but it took 48 years for work to commence at Harappa following Cunningham's first report of an Indus seal from the site. The published documents indicate that this object was a key to maintaining scholarly interest in the site. Everyone with a professional interest in ancient Indian history at that time knew of this find and of the other seals as they were published. The fact that the script was neither Brahmi nor Kharoshti was taken by them to indicate at least the possibility that there was a literate civilization in the subcontinent prior to the Mauryan Dynasty. Even if Cunningham's speculation were true that the seal was non-Indian because the animal depicted on it is not a zebu, the place of origin for this unknown system of writing was a prize considered to be worth seeking.

When work began at Harappa, with Rai Bahadur Daya Ram Sahni's excavations on both Mound AB and Mound F (Sahni 1920-21), the digging was done on quite a large scale. Sahni's first trench on Mound F was 152 meters (500 feet) long and 4.9 meters (16 feet) wide, and his work continued at that scale. These are very substantial exposures by modern standards and are an indication of the fact that Sahni and his contemporaries in Indian field archaeology were far from meek when it came to sinking a spade into a site.

The publication of the excavations at Harappa has not been complete, but the Vats (1940) volumes, for the work between 1920-21 and 1933-34, covers a great deal. There were four seasons of excavation at the site following Vats's departure that have not been published, save for very short notices, but I am told (George F. Dales, personal communication) that there are field records for some of this work that could be used to fill in gaps in the history of excavations at Harappa.

Table 2.1: Number of Excavation Seasons (to 1991) of selected sites of the Harappan Tradition.

Site	Seasons	Site	Seasons
Harappa	26	Banawali	5
Mohenjo-daro	15	Hulas	5
Mehrgarh	11	Sarai Khola	5
Kalibangan	10	Prabhas Patan	5
Sanghol	9	Balakot	4
Lothal	8	Shortugai	4
Mundigak	8	Ghazi Shah	4
Rojdi	8	Nindowari	3
Noh	7	Pabumath	3
Allahdino	6	Surkotada	2
Daimabad	6	Bara	2
Nausharo	6	Chanhu-daro	2
Rangpur	6	Jhukar	2
Rehman Dheri	6	Desalpur	1
Amri	5	Kulli	1
Balu	5	Mehi	1

The most recent excavation at the site by the University of California, Berkeley, Harappa Project, has been undertaken in conjunction with Pakistan's Department of Archaeology and Museums. This program of excavation and analysis has incorporated a diverse staff from a number of institutions. Their preliminary reports on the five years of work at the site have been substantial, well-illustrated documents.

The pace of archaeological work at Harappa that emerges from these notes and observations has a place of considerable historical interest in both the story of South Asian archaeology and the history of the discipline in general. Rather than engaging in what would be a rather long narrative I have condensed this history to a chronological listing with annotations outlining what I believe to be the highlights of this history.

Archaeological Discovery at Harappa: a Chronology

1826: Charles Masson is the first European visitor to subsequently report on Harappa. He suggests that the site is Sangala, the capital of King Porus, whom Alexander the Great defeated in 326 BC (Masson 1844, Vol. I:452).

1831: Sir Alexander Burnes visits Harappa. He is the second European to recognize it as an archaeological site of importance. Burnes also visits the site of Amri in Sindh as a part of his exploration of the Indus River (Burnes 1834, Vol. III:137).

1853: Sir Alexander Cunningham makes his first visit to Harappa. He finds the mounds in good condition (Cunningham 1875:108).

1856: Sir Alexander Cunningham makes his second visit. The mounds are still in good condition (Cunningham 1875:108).

1872-73: Sir Alexander Cunningham makes his third visit. He notes that the mounds have been subjected to brick robbing, and he conducts a small excavation. He publishes a plan of the site (Figure 2.1) and selected artifacts including a unicorn seal belonging to a Major Clark. Because the bull on the seal has no hump, Cunningham suggests that it is non-Indian in origin (1875:108).

1884: Mr. J. Harvey, Inspector of Schools, Multan, purchases an inscribed bar seal from an agriculturalist at Harappa on November 21, 1884 (Dames 1886). The date that Mr. Harvey acquired the seal is given as "December 1885" in Fleet (1912:700).

1886: Mr. T.A. O'Connor, District Superintendent of Police, digs up a unicorn seal at Harappa in, or shortly before, August 1886. This seal is given to M. Longworth Dames and published by J.F. Fleet (1912) along with the Cunningham and Harvey seals.

1909: Pundit Hira Nanda Sastri is sent to Harappa in January, 1909, by Dr. J.Ph. Vogel, Officiating Director General of the Archaeological Survey of India at the time. Sastri reports that the mounds are not likely to repay excavation (Sahni 1920-21:9).

1914: Sir John Marshall sends Henry Hargreaves to assess the mounds for excavation. Hargreaves is not enthusiastic about excavation but recommends that work begin on Mound F at the northern end of the site near the old bed of the river Ravi (Majumdar 1939:99).

1916-17: Rai Bahadur Daya Ram Sahni visits Harappa in December 1917. He prepares a site plan and begins the process of bringing the site under the protection of the government. He notes that brick robbing continues at the site (Sahni 1916-17).

1920-21: Rai Bahadur Daya Ram Sahni excavates on Mounds F and AB, as indicated on Cunningham's 1875 site plan. On Mound F, where what has been called the "granary" came to be exposed, he puts in a trench 152 meters (500 feet) long and 4.9 meters (16 feet) wide. On Mound AB he finds a building which incorporates stone with supposed "Mauryan polish." He finds two more seals that are said to be in pre-Mauryan contexts (Sahni 1920-21).

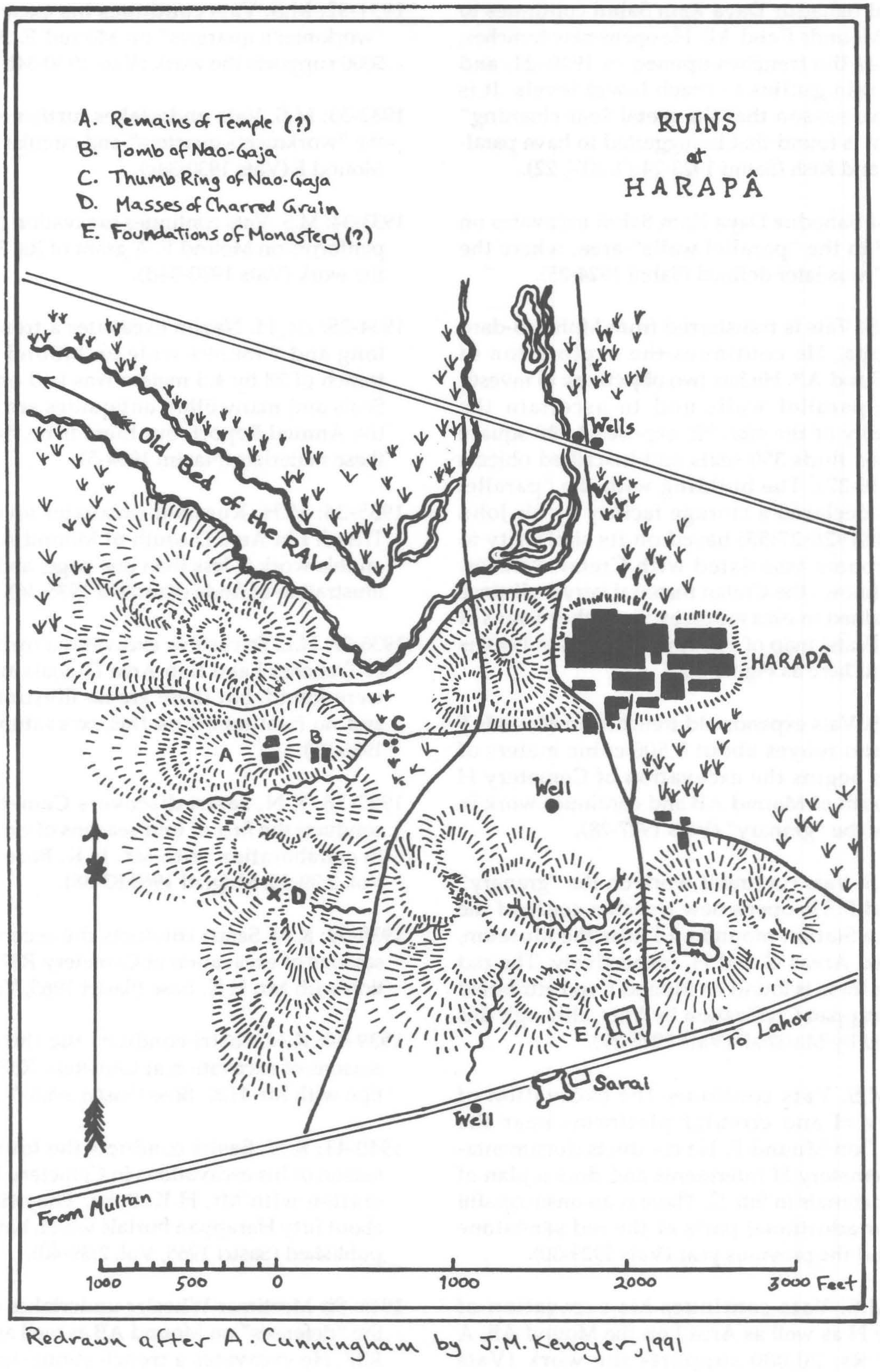

Figure 2.1: "Ruins of Harapâ" redrawn after Cunningham (1875).

1923-24: Rai Bahadur Daya Ram Sahni continues to excavate Mounds F and AB. He opens new trenches, or expands the trenches opened in 1920–21, and uses the rain gullies to reach lower levels. It is during this season that the metal "ear cleaning" implement is found that is suggested to have parallels at Ur and Kish (Sahni 1923-24:Pl. XIX, 22).

1924-25: Rai Bahadur Daya Ram Sahni excavates on Mound F in the "parallel walls" area, where the "granary" was later defined (Sahni 1924-25).

1926-27: M.S. Vats is transferred from Mohenjo-daro to Harappa. He continues the exploration of Mounds F and AB. He has two objectives: to investigate the parallel walls and to ascertain the stratigraphy of the site. He exposes 4,690 square meters and finds 350 seals and inscribed objects (Vats 1926-27). The building with the "parallel walls" is declared a storage facility by Sir John Marshall (1926-27:53) based on its similarity to storage rooms associated with Cretan Palaces. Marshall knows the Cretan material very well since he was trained in excavation by Sir Arthur Evans at Knossos. [Vats' map of Harappa (from Vats 1940) is reproduced here as Figure 2.2.]

1927-28: M.S. Vats expands old trenches on Mounds F and AB and moves about 8,500 cubic meters of earth. He begins the excavation of Cemetery H burials south of Mound AB and continues work in the area of the "granary" (Vats 1927-28).

1928-29: M.S. Vats continues work on the "granary" on Mound F. He opens new trenches south of the Old Police Station mound and near the Museum, designated Areas G and H, respectively. The red sandstone torso is found on Mound F and attributed to the Harappan Civilization by Vats, although this is disputed by Marshall (Vats 1928-29).

1929-30: M.S. Vats continues the excavation of Cemetery H and circular platforms near the "granary" on Mound F. He conducts documentation of Cemetery H interments and does a plan of skeletal materials in Site G. There is an unsuccessful search for additional parts of the red sandstone torso found the previous year (Vats 1929-30).

1930-31: M.S. Vats continues his excavation of Cemetery H as well as Area J on the Mound AB. A grant of Rs. 20,000 supports the work (Vats 1930–34a).

1931-32: M.S. Vats continues his excavation at the "workmen's quarters" on Mound F. A grant of Rs. 5000 supports the work (Vats 1930-34b).

1932-33: M.S. Vats undertakes further excavation of the "workmen's quarters" and circular platforms on Mound F (Vats 1930-34c).

1933-34: M.S. Vats continues excavation of the circular platforms on Mound F. A grant of Rs. 3000 supports the work (Vats 1930-34d).

1934-35: Dr. H. Nazim excavates a trench 27 meters long and 9 meters wide on Mound F. A second trench of 28 by 4.5 meters was laid on Mound AB. Seals and many other antiquities are published in the Annual Report, but there is no final report on these materials (Nazim 1934-5).

1935-36: M.H. Kuraishi excavates an extension of Trench I in Area D south of Mound AB. His report on this work is less than one page, and there are no illustration of finds (Kuraishi 1935-36).

1936-37: H.L. Srivastava excavates a further extension of Trenches I and II in Area D. Seals and terracottas were found, but there are no illustrations of seals and no final report on this excavation (Srivastava 1936-37).

1937-38: K.N. Sastri discovers Cemetery R37 and conducts the first of four seasons of excavation there in collaboration with Mr. H.K. Bose (Sastri 1965, Vol. 2:39-40; Mughal 1968:83-88).

1938-39: K.N. Sastri conducts the second of his four seasons of excavation at Cemetery R37 in collaboration with Mr. H.K. Bose (Sastri 1965, Vol. 2:39-40).

1939-40: K.N. Sastri conducts the third of his four seasons of excavation at Cemetery R37 in collaboration with Mr. H.K. Bose (Sastri 1965, Vol. 2:39-40).

1940-41: K.N. Sastri conducts the fourth and final season of his excavations in Cemetery R37 in collaboration with Mr. H.K. Bose. They find a total of about fifty Harappan burials which have never been published (Sastri 1965, Vol. 2:39-40).

1946: Sir Mortimer Wheeler undertakes excavation of the "defenses" on Mound AB as well as in Cemetery R37. He excavates a trench connecting Cemetery R37 with Cemetery H. Cemetery H habitations are

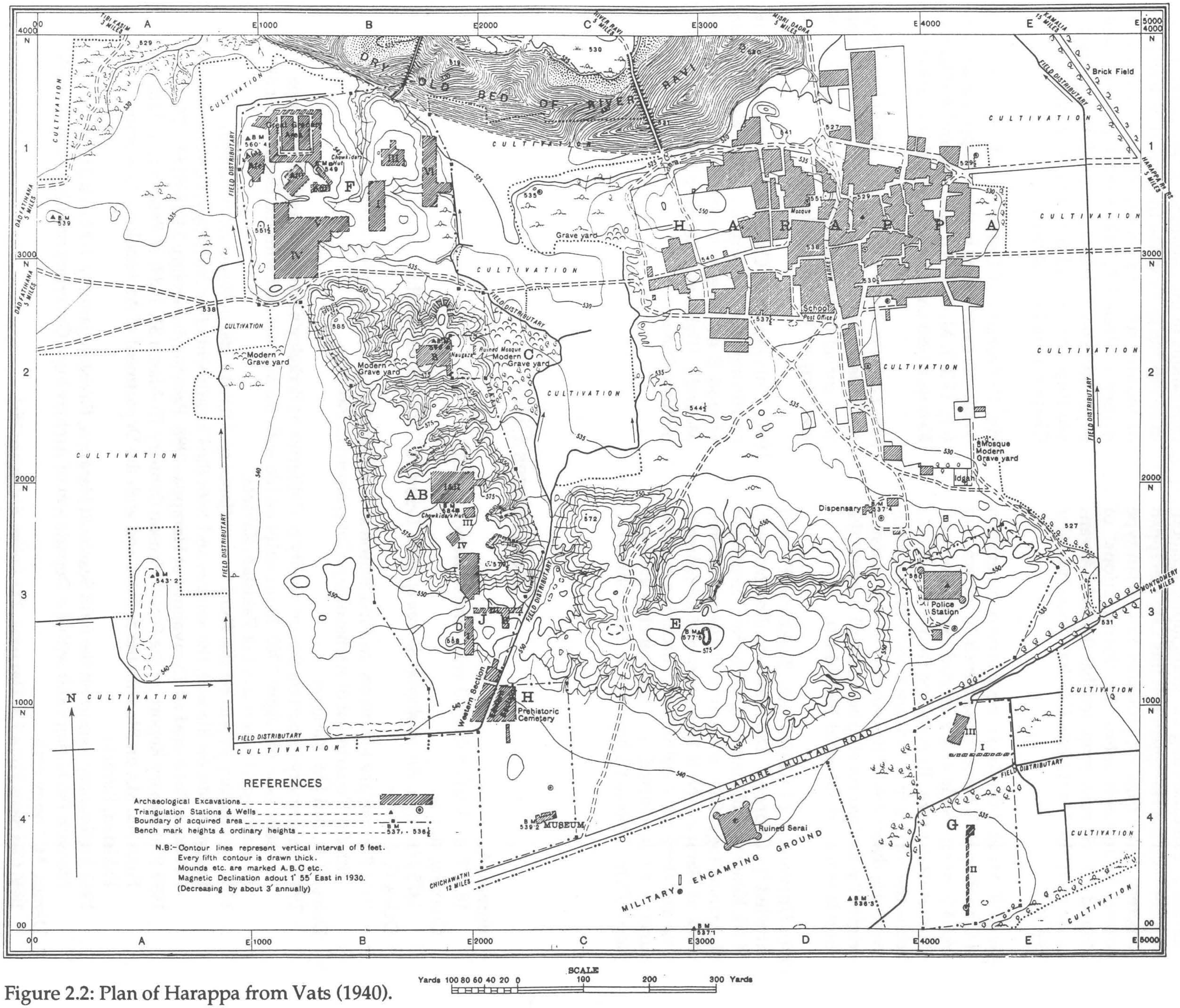

Figure 2.2: Plan of Harappa from Vats (1940).

found in the vicinity of the west "gates" and "terraces," demonstrating the stratigraphic relationship between the Harappan and this Late Harappan cemetery. Deep digging produces Kot Dijian type pottery in deposits below the "fortifications" of Mound AB. Wheeler proposes that the Indo-Aryans destroyed the Harappan Civilization (Wheeler 1947).

1966: M.R. Mughal conducts one season of excavation in Cemetery R37. He lays one trench 30 meters long and 4.5 meters wide and a second excavation unit six meters square. Burials are found one meter below the surface in the square trench. Eleven interments are discovered. The cemetery was apparently originally located on sloping ground outside the bounds of the city (Mughal 1968:63-68).

1986: University of California, Berkeley, Project directed by George F. Dales and co-directed by J. Mark Kenoyer, collaborating with the Department of Archaeology, Government of Pakistan, resumes work at Harappa. New laboratory and administrative quarters are established, intensive surface surveys are conducted, and test trenches are excavated (Dales 1986 and Chapter 13 in this volume).

1987: University of California, Berkeley, Project begins excavations in the Harappan phase cemetery (R37), in an erosion gully in the the central eastern portion of Mound AB, and on top of the northwestern corner of Mound E. Palaeoenvironmental studies begin and conservation and analytical procedures are implemented (Dales and Kenoyer 1987 and Chapter 13 in this volume).

1988: University of California, Berkeley, Project continues excavations in the Harappan phase cemetery (R37), Mound AB, and Mound E (Dales and Kenoyer 1988 and Chapter 13 in this volume).

1989: University of California, Berkeley, Project continues excavations on Mound AB and in northwest corner of Mound E (Dales and Kenoyer 1989 and Chapter 13 in this volume).

1990: University of California, Berkeley, Project continues excavations on northwest corner of Mound E and begins excavation on south side of Mound E (Dales and Kenoyer 1990 and Chapter 13 in this volume).

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Cover art: Bowl on Stand H88-1002/192-17 associated with Burial 194a
in Harappan Phase Cemetery (see Figure 13.18).

3

Pedology and Late Quaternary Environments Surrounding Harappa: A Review and Synthesis

Ronald Amundson and Elise Pendall
University of California-Berkeley

A review and synthesis of pertinent pedological, geological, and paleoenvironmental studies in the vicinity of Harappa (District Sahiwal, Punjab, Pakistan) suggest that a wealth of research opportunities exists for earth scientists interested in contributing to an understanding of the origins and later decline of the Indus civilization.

Harappa lies near the apex of the Holocene alluvial fan of the river Ravi on an alluvial deposit of late Pleistocene age. Soil patterns around Harappa indicate several periods of river meandering and channel infilling.

Stable isotopes in pedogenic carbonates of a soil buried by early occupation offer potential insights into pre-Harappan environmental conditions. Although carbon isotope ratios are difficult to interpret unambiguously, they suggest either a very arid, sparsely vegetated site (matching presumed latest Pleistocene conditions) or a nearly pure C_4 flora, indicative of a tropical grassland (presumed early Holocene conditions). Oxygen isotope ratios in the carbonate are also difficult to interpret due to a lack of knowledge of the isotopic composition of present precipitation. Depending on the temperature at which the carbonates formed, the oxygen isotope ratios in the carbonate could indicate that pre-Harappan conditions were either similar to the present or that a stronger monsoon may have existed.

The ancient city of Harappa, like other cities of the Indus civilization, should be studied in the context of its contemporaneous environment (Butzer 1982), as well as in relation to conditions which preceded its inception and followed its demise. Environmental and geologic factors such as climate, vegetation, flooding, and sedimentation, to name a few, not only determine the suitability of a site for habitation, but can ultimately help shape the culture which evolves (Amundson and Jenny 1991).

Numerous approaches are becoming available to archaeologists interested in reconstructing past environments. In this paper we report on our initial pedological work at Harappa and its relationship to the more regional conditions in the Punjab. In addition, we review some of the important previous studies of the climate and geology of the region to provide a context for our work at Harappa and to provide a general overview of much of the area once inhabited by the peoples of the Indus Valley Civilization.

Climate of the Punjab

The present day summer monsoon circulation of Pakistan is driven by the relative warmth of the South Asian land mass relative to the surrounding oceans (COHMAP Members 1988). Winters are cool to cold, with occasional disturbances originating from the Mediterranean Sea. From April to June, land mass temperatures increase greatly, with maximums of 50°C or more being recorded in the southern Punjab (Pakistan Meteorological Department 1986). These temperatures set up the Indus low, which is associated with a south-westerly, but dry, monsoon. During May, an associated low pressure trough develops over the Ganges, which is fed by moist air from the Bay of Bengal. The upward surging, warm moist air of this trough reaches the Punjab in late June or early July, marking the onset of summer precipitation which commonly continues until late August. From September through November, a transition from the

summer monsoon to the cool, dry winter period occurs. At Sahiwal, about 12 km NE of Harappa, the mean annual temperature is about 26°C and the mean annual precipitation is about 260 mm, 70% of which falls between July and September (Greenman et al. 1967).

The general character of the prehistoric climate of South Asia has been debated for many years (see Meadow 1989 for summary). While some scholars feel that there has been little change in climate since the end of the Pleistocene, others suggest that it has varied greatly from the last glacial maximum (18,000 years BP) to the present. Model calculations for the past 18,000 years, based on input parameters of orbitally determined insolation, ice-sheet orography, atmospheric CO_2 concentrations, and sea surface temperatures (as well as other inputs), suggest that during the late Pleistocene, South Asia was colder and drier than the present, with a greatly weakened summer monsoon due to factors such as highly reflective ice sheets (COHMAP Members 1988). This prediction appears to be supported by field evidence in the sediment stratigraphy of several small salt lakes in the arid to semi-arid belt of western Rajasthan, India (Singh 1971; Singh et al. 1974; Bryson and Swain 1981). Pre-Holocene (>≈10,000 years BP) sediments consisting of loosely-packed aeolian sand, indicate that the lakes were dry and that the presently stabilized sand dunes were active. Singh et al. (1974) have interpreted the pre-Holocene conditions to have been extremely arid and possibly windy.

The increased summer, and decreased winter, insolation proposed for the early Holocene would have greatly enhanced the summer monsoon of South Asia. The Asian land mass may have been 2° to 4°C warmer than present, and increased summer rainfall, relative to the present, is predicted to have fallen over South Asia. After 6,000 years BP, the summer insolation appears to have decreased, with the monsoonal winds and associated rainfall predicted to have declined to present levels. Singh's interpretations of the lake sediments of western Rajasthan appear to support these model predictions and also provide a more detailed environmental history of the region. Laminated, pollen-bearing, lacustrine sediments accumulated from the early Holocene until approximately 3,000 years BP, at which time there is possible evidence for desiccation (Singh 1971). Qualitatively, the pollen in all the lacustrine sediments suggests far greater precipitation than at the present time. Using the lake pollen data in conjunction with statistical relationships between present-day pollen and climate, Bryson and Swain (1981) have estimated that the precipitation of western Rajasthan between 10,000 to ≈3,500 years BP may have been three times that of the present. Singh (1971) and Singh et al. (1974) have distinguished several distinct pollen zones within the sediments, with each zone indicative of changing climatic (as well as cultural) conditions.

The early Holocene appears to have been an open steppe rich in grasses, *Artemisia*, and sedges. At approximately 7,500 years BP, the appearance of charcoal and Cerealia-type pollen is believed by these authors to signal the appearance of early agriculture and land alteration. An apparent increase in mesophytic vegetation between 5,000 to 3,000 years BP was interpreted by Singh (1971) and Singh et al. (1974) to possibly represent the moistest period of the Holocene. However, the later analysis of the data by Bryson and Swain (1981) seems to indicate that the period was not greatly different than those that preceded it.

A reduction in annual precipitation rates would have been especially detrimental to the non-riverine settlements in western Rajasthan, and the desiccation of the lakes at approximately 4,000 to 3,000 years BP may correspond to the disappearance of the Indus culture in western Rajasthan (Agrawal et al. 1964; Singh 1971). However, the influence of such a climate change on riverine settlements, such as Harappa and Mohenjo-daro, is more difficult to assess. (See Misra 1984 for a critical assessment of Singh's data).

Geology and Geomorphology of the River Ravi

The present day floodplains of the Indus river system lie atop a sequence of alluvial deposits many thousands of feet thick. The rapidly changing channels of the Indus and its tributaries attracted the attention of many of the early geographers in the region (Raverty 1892; Oldham 1874; Oldham 1887), many of whom recognized the significance to archaeological and historical studies (Wood 1924; Whitehead 1932).

The upper region of the Ravi (as well as other Indus tributaries) is entrenched several or more meters into its own, Pleistocene-aged, alluvium (Figure 3.1) (Abu Bakr and Jackson 1964), while in its lower reaches, prior to entering the Chenab, the older alluvium is buried beneath alluvium of Holocene age. The Pleistocene-aged alluvial terraces which rise prominently above the present floodplains, are locally referred to as *bar* (Whitehead 1932; Mian and Syal 1986) and have been recognized since some of the earliest studies as containing prominent concentrations of *kankar*, or pedogenic calcium carbonate nodules (Wood 1924). It has been recognized that these geomorphically stable terraces are sites for settlements of great antiquity (Wood 1924).

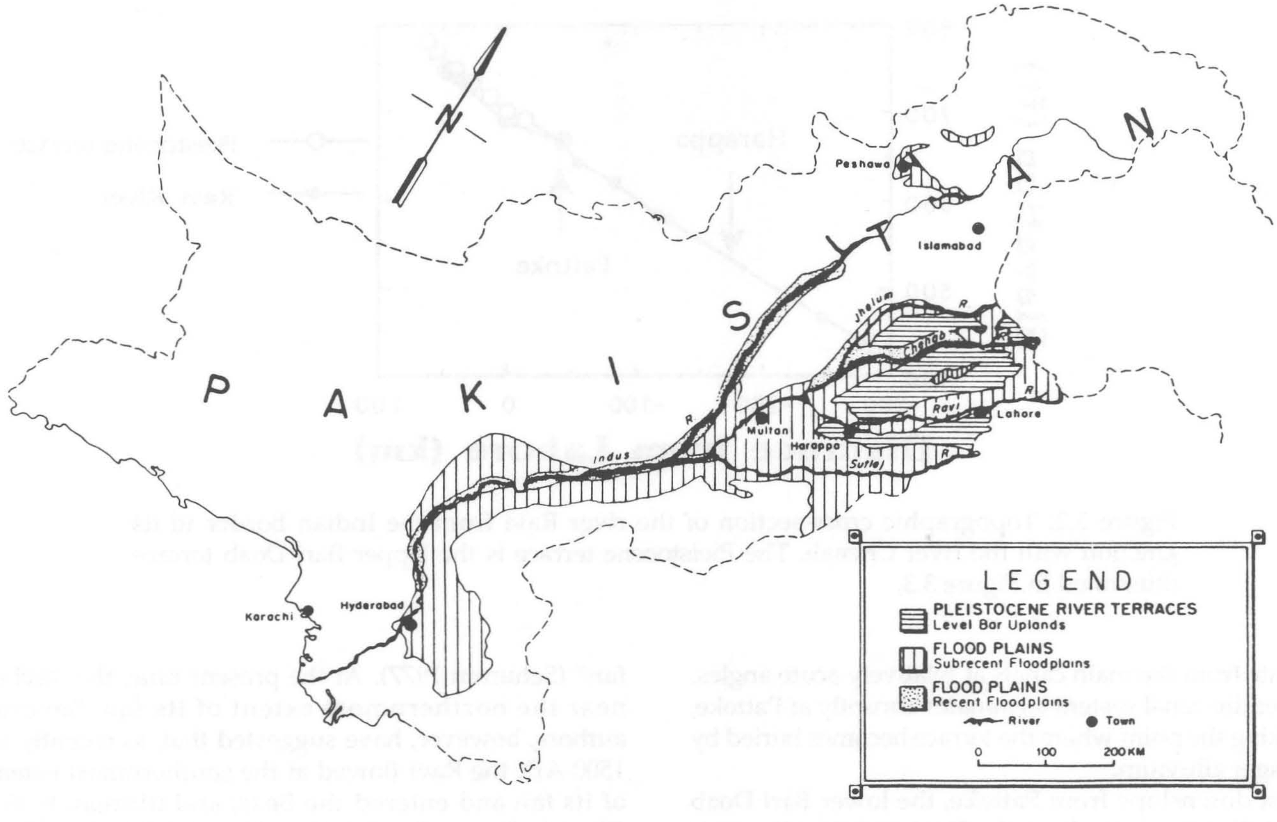

Figure 3.1: Generalized geomorphological map of Pakistan showing major cities, site locations, rivers, and alluvial landforms. Modified from Mian and Syal (1986), taken from Pendall and Amundson (1990a).

Whitehead (1932) suggested that Harappa lies on an old terrace of the Ravi and provided a very general map showing the partial extent of this terrace.

Detailed geomorphic studies of the central section of the river Ravi (including the area around Harappa) have not been made, although a reconnaissance study of the upper section (mainly in India) (Mahr 1986) and general studies of its lower section (near the river Chenab) (Wood 1924; Wilhelmy 1969) have been published. In this paper, we present a preliminary map of a portion of the geomorphology from the Indian border to the river Chenab. The map was constructed based on interpretations of topographic maps published by the U.S. Army Corps of Engineers (1955) and Couchman (1936). Scattered elevation data from the maps were used to prepare topographic cross sections. The pattern of irrigation canal systems, which, as Wood (1924) noted, are mainly the controlled diversions of present rivers into channels that follow old beds, was also used to assess landform patterns.

The present gradient of the river Ravi is roughly linear from the Indian border to the river Chenab (Figure 3.2), with a slope of approximately 29 cm/km (Table 3.1). The city of Lahore lies atop an old alluvial deposit into which the present river Ravi has entrenched approximately 10 m. This *bar*, or terrace, is more steeply dipping than the present Ravi (Table 3.1) and, based on its slope, should plunge beneath the present land surface near the village of Pattoke, approximately 60 km SW of Lahore (Figure 3.3). Major changes in irrigation patterns near Pattoke reveal this geomorphic change. The age of the terrace on which Lahore resides is certainly Pleistocene in age based on *kankar* development in the soil (Mian and Syal 1986) and its height above the present river Ravi. A more precise assignment of age is not possible without detailed fieldwork and radiometric dating.

The major irrigation canal on the Pleistocene terrace is the Upper Bari Doab canal. For the purposes of this paper, we will informally name this terrace the Upper Bari Doab terrace. On this terrace, distributary channels

Table 3.1: Calculated Slopes of some Landforms in the Vicinity of Harappa.

Landform	Slope (m/km)
River Ravi	0.287
Pleistocene Terrace (Upper Bari Doab)	0.340
Chenab River (near Multan)	0.204

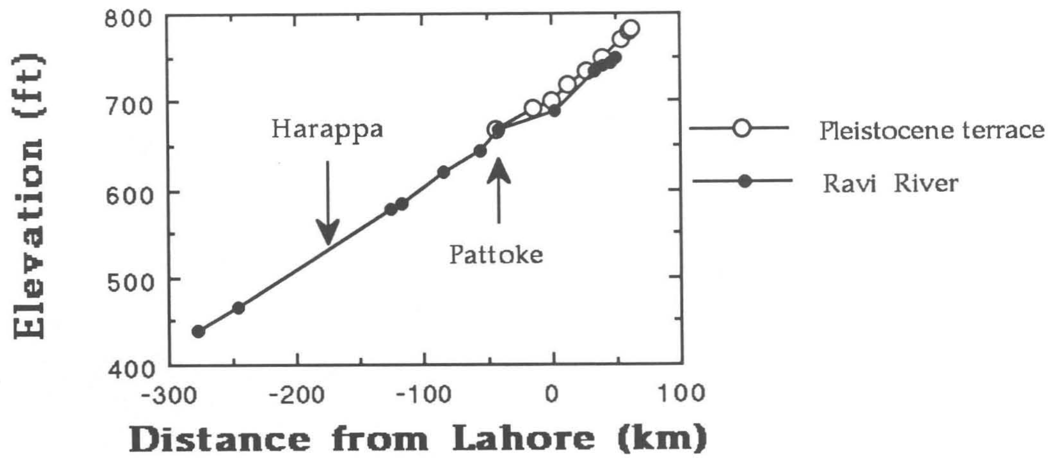

Figure 3.2: Topographic cross-section of the river Ravi from the Indian border to its junction with the river Chenab. The Pleistocene terrace is the Upper Bari Doab terrace illustrated in Figure 3.3.

radiate from the main canals at relatively acute angles. The entire canal system terminates abruptly at Pattoke, marking the point where the terrace becomes buried by younger alluvium.

Just downslope from Pattoke, the lower Bari Doab canal diverts water from the Ravi and distributes it over a relatively low, narrow terrace to the south of the present Ravi floodplain. In this paper, we will informally call this the Lower Bari Doab terrace. The distributary channels from this canal radiate outward at greater angles than those of the Upper Bari Doab terrace. This canal system ends approximately 25 km SW of Sahiwal (formerly Montgomery), which is near Harappa. On the south, the terrace (and the irrigation system) ends at a prominent escarpment that drops down to the abandoned channel of the river Beas. On the north, an escarpment is not prominently indicated on topographic maps. The slope of the terrace is not known due to inadequate elevation data on available maps. The exact age of the terrace is also not known, although generalized geologic (Abu Bakr and Jackson 1964) and geomorphic maps (Mian and Syal 1986) suggest a Pleistocene age. The terrace is younger than the Upper Bari Doab terrace since its alluvium buries that of the older terrace. Whitehead (1932) suggested that Harappa lies on the edge of what we call the Lower Bari Doab terrace, but, as will be discussed in the following section, the relationship is not unambiguous.

To the southwest of Harappa, numerous irrigation canals branch off mainly to the south of the present day river Ravi and extend as far as Multan (Figure 3.3). These canals appear to outline the major area of Holocene deposition by the Ravi or its "wet alluvial fan" (Schumm 1977). At the present time, the Ravi is near the northernmost extent of its fan. Several authors, however, have suggested that, as recently as 1500 AD, the Ravi flowed at the southernmost extent of its fan and entered the Beas, and ultimately the Chenab, far south of Multan (Wood 1924; Wilhelmy 1969). Thus, in roughly the past 500 years, the Ravi has migrated northward almost 70 km.

The rapid and extreme shifts in river courses on the Indo-Gangetic plain are well documented (Cole and Chitale 1966; Lambrick 1967; Wilhelmy 1969). Rapid rises in the base of river beds, due to deposition of alluvium, lead to sudden breaks in levees, particularly during flood events. New channels are then formed in adjacent areas of lower elevation. This process has been termed river avulsion (Schumm 1977).

River avulsion has important archaeological significance. For example, Alexander sailed his barge to the junction of the Chenab and Ravi rivers in 326-325 B.C. The exact location of this event is now difficult to assess given the dynamic nature of these two rivers (Wood 1924). As a second example, archaeological sites of great antiquity may not have been preserved on the Holocene fan of the river Ravi, to the southwest of Harappa, as a result of frequent river avulsion and sediment deposition.

For Harappa itself, the dynamics of the river Ravi may have played a significant role. Although Harappa appears to be upslope of the apex of the Ravi's alluvial fan, the river does appear to have migrated significantly, near Harappa and also upstream, within its relatively narrow valley. Harappa lies some 12 km south of the present Ravi river, but the modern town and ancient site are located on the southern bank of a

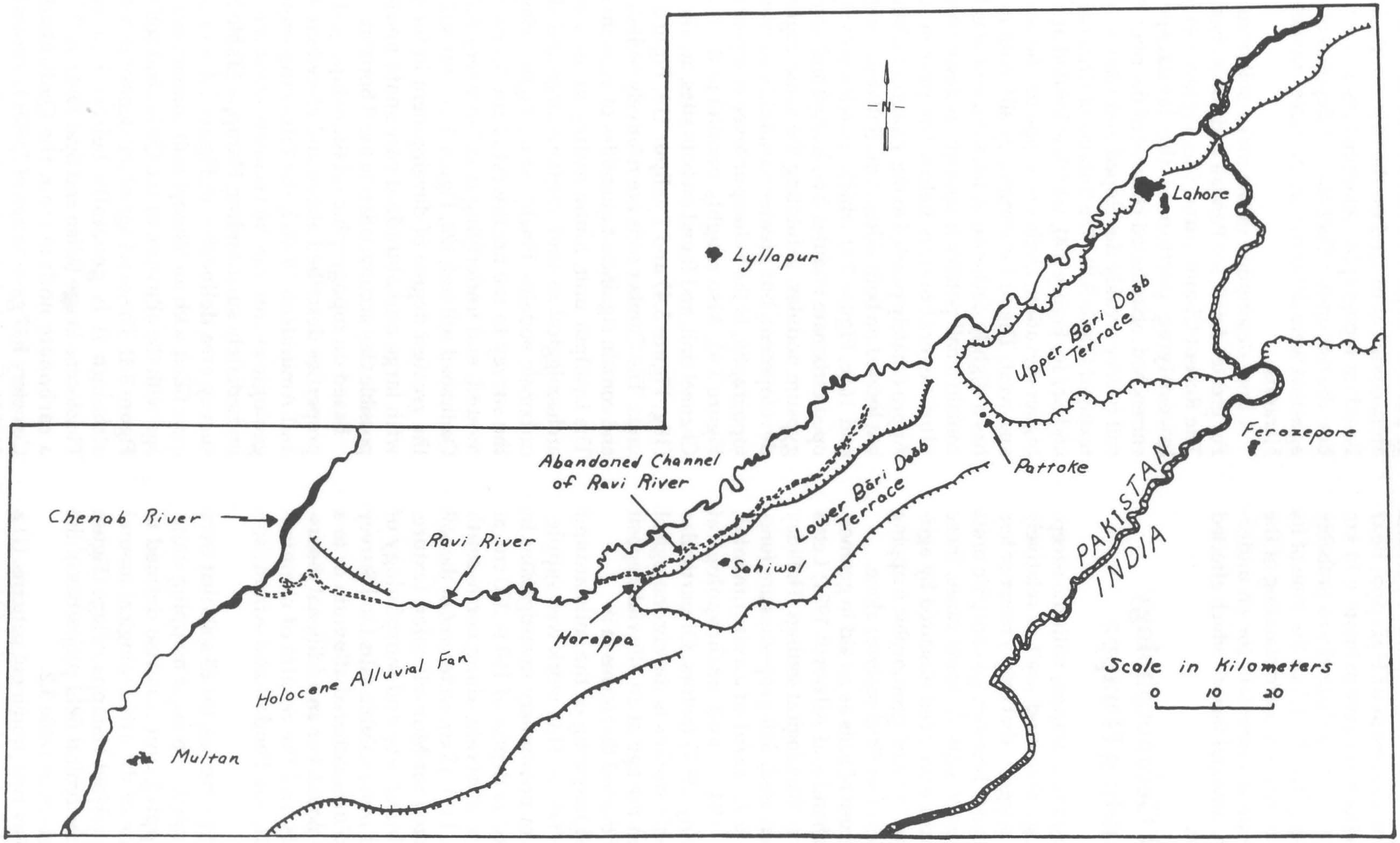

Figure 3.3: A reconnaissance geomorphological map of a section of the river Ravi. The relative age sequence of the alluvial deposits, from oldest to youngest is: Upper Bari Doab terrace, Lower Bari Doab terrace, and Holocene alluvial fan. Both the Upper and Lower Bari Doab terraces are believed to be Pleistocene in age.

conspicuous channel that often carries water during the summer monsoon floods. This channel bifurcates from the Ravi 83 km upstream of Harappa, near Pattoke, and rejoins the river approximately 14 km downstream from the site. This channel was probably once the main course of the Ravi, but the time of its abandonment is unknown. An understanding of the timing of these events is important for an understanding of the environmental factors which affected the people of Harappa.

Soils and Geomorphology Surrounding Harappa

The topography around Harappa, with the exception of the archaeological mound itself, is relatively subdued. Field work suggests that only a meter or less of relief commonly exists between geomorphic units of significantly different ages. In some cases, these topographic differences have been obscured by agricultural activity. Thus, detailed geomorphic mapping is difficult on the basis of surficial features alone.

In recent years, the use of soils as an aid in geomorphic mapping (Marchand and Allwardt 1981; Lettis 1985), particularly in archaeological settings (Holliday 1990), has greatly increased. Soil properties are functionally related to a handful of environmental, geological (Jenny 1941), and anthropological (Amundson and Jenny 1991) factors. Of particular interest in geomorphic studies is the chronological relationship between the age of an alluvial deposit and the properties of the soil that forms in it.

In 1988, a detailed mapping of the soils around Harappa was undertaken. This work was supplemented with results of preliminary investigations in 1987. Soils were cored to depths of 150 to 300 cm, at approximately 200 m intervals, along north–south transects (Figure 3.4). Each 15 cm increment of the soil core was characterized for Munsell color, texture, consistence, and abundance and morphology of calcite, gypsum, and more soluble salts (Soil Survey Staff 1981). Depth to unweathered alluvium or to a water table was also noted. For an additional discussion of the methods and the results of chemical analyses of the soils, see Pendall and Amundson (1990a).

Based on their field properties, the 65 soils that were examined were grouped into eight mapping units. One additional mapping unit was also defined to show the distribution of the archaeological mound and the presently-inhabited Harappa village (Figure 3.4). A summary of the typical field properties of the major soil types are given in Table 3.2.

The soil units display two prominent patterns: (1) a sinuous east-west band to the north of Harappa (abandoned channel of the river Ravi) and (2) a series of parallel, semi-circular bands surrounding the archaeological mound on the east, south, and west. Based on topographic relationships and soil properties, the soil units reflect alluvial deposits of differing ages that were deposited in meander channels around Harappa.

A brief description of the major soil units follows. For greater detail, see Pendall and Amundson (1990a). The Recent Channel unit (Rc, Figure 3.4) is on the lowest-lying portion of the landscape in the entrenched, abandoned channel of the river Ravi. The soil is very weakly developed and relatively coarse-textured (Table 3.2). The Subrecent Channel unit (Sc and Sc/16, Figure 3.4), which is located at a slightly higher elevation, circles Harappa on the east, south, and west. The soil is commonly silt loam in texture, has a slightly darkened A horizon, and was found to contain small pottery fragments in unweathered alluvium several meters below the present surface. Approximately parallel to the Subrecent Channel unit, but located on both sides, is the Sultanpur soil unit (16 and 16gc, Figure 3.4) which contains weakly-developed carbonate nodules (i.e., *kankar*) and occasionally gypsum nodules. Exhibiting the same degree of soil development, but greater variability in texture and topography, is the Sultanpur levee complex (17, 17S, Figure 3.4). Also roughly parallel to the Subrecent Channel unit, and found on both sites, are the Gamber (18g, Figure 3.4) and Lyallpur (19, Figure 3.4) soil units. The Gamber soils are relatively well-developed and contain significant quantities of gypsum nodules. The Lyallpur unit, found mainly to the west of the archaeological mound, contains large and abundant carbonate nodules. Finally, at the highest elevation in the survey to the northwest of the archaeological mound, and underlying it at Cemetery R37, is the Qadirabad soil unit (20, Figure 3.4). This soil exhibits the greatest degree of development in the vicinity, with large and abundant carbonate nodules and possible clay accumulation in the B horizon.

Based on topographic relationships and the soil properties described above and elsewhere (Pendall and Amundson 1990a), the following sequence of geologic events can be reconstructed for the area immediately surrounding Harappa (Table 3.3). The survey area delineated in Figure 3.4 was probably once filled with an alluvial unit contemporaneous in age with the alluvium of the Qadirabad soil unit (20, Figure 3.4). The exact age of the deposit is not known, although it is generally believed to be latest Pleistocene in age (Mian and Syal 1986). A ^{14}C date on a carbonate nodule from the Qadirabad soil in Cemetery R37 gave an age of 7,080±120 years BP (Beta 21520). Considering that it takes at least several thou-

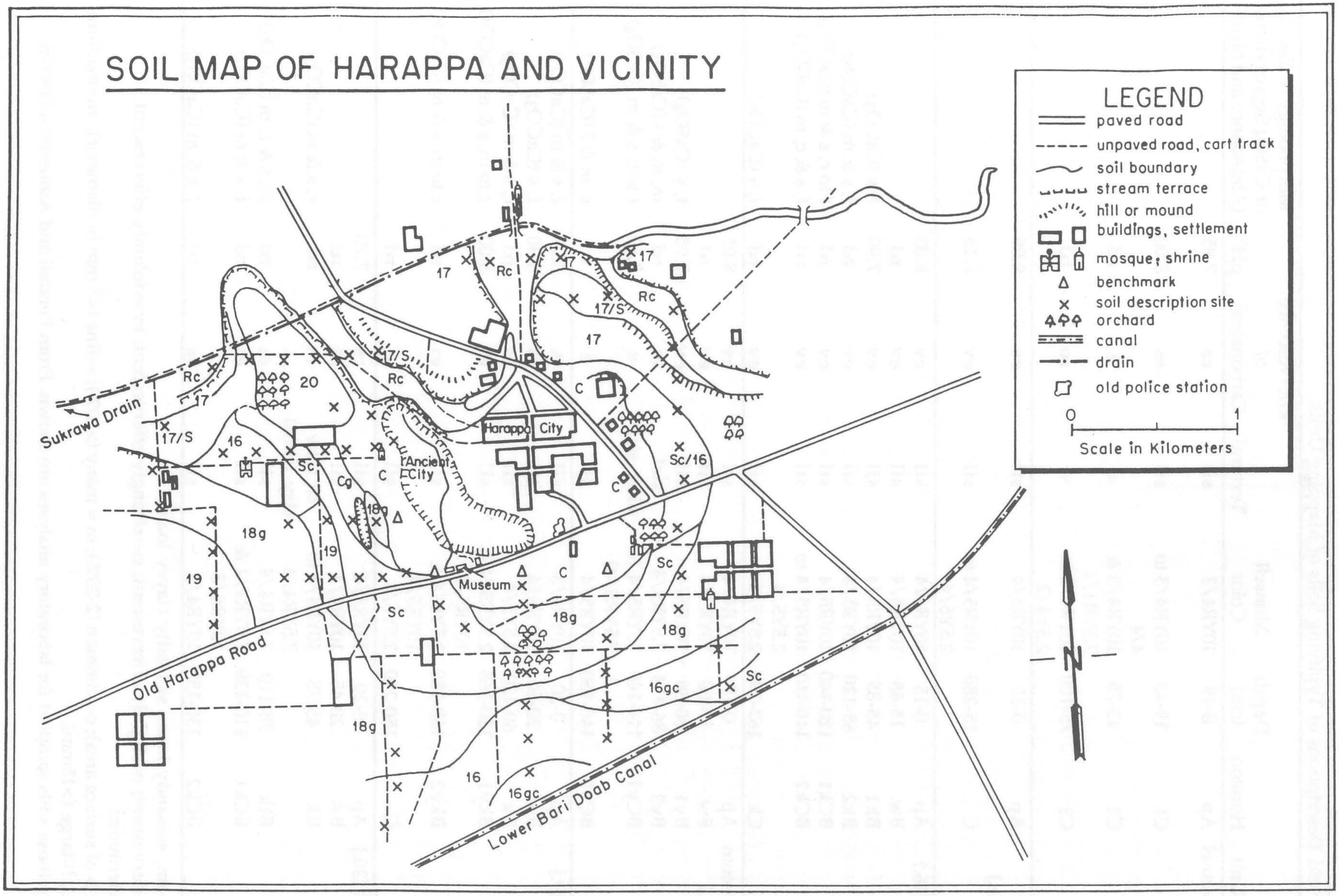

Figure 3.4: Soil map of the region immediately surrounding Harappa. Mapping units are discussed in the text. Abbreviations for mapping units are: C, Cg: Cultural material, Cultural material with gypsum; Rc: Recent channel; Sc, Sc/16: Subrecent channel, Subrecent channel overlying Sultanpur; 16, 16gc: Sultanpur, Sultanpur - gypsum plus calcite phase; 17, 17/S: Sultanpur Levee Remnant Complex, Sultanpur Levee Remnant Complex - shallow over sand; 18g: Gamber; 19: Lyllpur; 20: Qadirabad. From Pendall and Amundson (1990a).

Table 3.2: Field Descriptions of Typifying Soils of Mapping Units.

Mapping Unit	Horizon	Depth (cm)	Munsell Color	Texture[1]	Effervescence of Carbonates[2]	pH[3]	Morphology of $CaCO_3$ or $CaSO_4$ Segregations (Abundance and Size)[4]
Recent Channel [Rc.]	Ap	0-19	10YR4/3	sil	es	7.95	
	C1	19-43	10YR4/3 to 4/4	sil	es	8.00	
	C2	43-75	10YR4/3 & 7.5YR4/4	sl	e	nd	
	C3	75-100	10YR4/2 to 2.5Y4/2	sl	eo	nd	
Subrecent Channel [Sc.]	Ap	0-15	10YR4/4	sil	ev	8.05	
	C	15-280	10YR5/4 to 2.5Y5/4	sil	ev	8.15	
Sultanpur [16.]	Ap	0-15	10YR4/4	sil	ev	8.05	
	Bw	15-45	10YR5/4	sil	ev	nd	
	Bk1	45-85	10YR5/4	sil	ev	7.90	f, s ($CaCO_3$)
	Bk2	85-120	10YR5/4	sil	ev	nd	f, s & m ($CaCO_3$)
	BCk1	120-140	10YR5/4	sil	ev	nd	f to c, s & m ($CaCO_3$)
	BCk2	140-163	10YR5/4 to 2.5Y5/4	sil	ev	nd	f, s & c, m ($CaCO_3$)
	Ck	163-193	2.5Y5/4	sil	ev	nd	f, s ($CaCO_3$)
Gamber, gypsum phase [18g.]	Ap	0-15	10YR4/4	sil	ev	8.05	
	Bw	15-60	10YR5/4	sil	ev	nd	
	By1	60-86	10YR5/4	sil	ev	7.95	f, s ($CaSO_4$)
	By2	86-114	7.5YR5/4	sicl	es	nd	m, m & l ($CaSO_4$)
	BCy1	114-140	10YR5/4 (& 7.5YR5/4)	sil(& sicl)	e	8.10	f to c, s & m ($CaSO_4$)
	BCy2	140-150	10YR5/4	sil	e	nd	c, m & l ($CaSO_4$)
Lyallpur [19.]	Ap	0-20	10YR4/3	sil	es	8.35	f, s & m ($CaCO_3$)
	Bw	20-60	10YR6/4	sil	es	8.30	f, s ($CaCO_3$)
	Bk	60-120	2.5Y5/4	sil	es	nd	c, s & m ($CaCO_3$)
	Bky1	120-168	2.5YR5/4 & 10YR5/4	sil	es	8.00	c to m, s & m ($CaCO_3$)
	Bky2	168-180	2.5Y6/4 & 10YR5/4	sil	es	nd	c to m, s & m ($CaCO_3$)
	C	180-210	2.5Y6/4	sil	e	nd	
Qadurabad [20.]	Ap	0-20	10YR4/4	sil	es	7.70	
	BA	20-45	10YR4/4	sil	es	nd	
	Bk	45-78	10YR4/4 to 7.5YR4/4	sil (few clay films)	es	nd	c, s & m ($CaCO_3$)
	Btk	78-110	7.5YR4/4	sil	es	nd	m, s & c, m ($CaCO_3$)
	BCk1	110-130	7.5YR4/4 & 10YR6/3	sil	es	nd	f, s & m ($CaCO_3$)
	BCk2	130-150	10YR4/3	sil	es	nd	f, s & m ($CaCO_3$)

1 sil=silt loam; sl=sandy loam; sicl=silty clayey loam.

2 eo=non-effervescent; e=slightly effervescent; es=strongly effervescent; ev=violently effervescent.

3 nd=not determined.

4 f=few (<2% of surface area); c=common (2-20%); m = many (>20%); s=fine (<5 mm in diameter); m=medium (5-15 mm); l=large (>15mm).

Note: Only those soils sampled for laboratory analyses are shown. From Pendall and Amundson (1990a).

Table 3.3: The Relative and Estimated Absolute Ages of the Mapping Units.

Relative Landform Age[1]	Map Units	Differentiating Features: Carbonate Morphology[2] (Stage)	Differentiating Features: B Horizon (Type)	Differentiating Features: Observable Landscape Position	Estimated Age (Years BP)
1 (Youngest)	Recent Channel	None	None	Entrenched Distributary Channel	<30[3]
2	Subrecent Channel	None	None	Level Floodplain	<4500[4]
3	Sultanpur, Sultanpur_{gc}	I to Early II	Bk, Bw	Level Floodplain	<2000 – >5000[5]
4	Gamber, Lyallpur	II	Bk, Bw, By	Level Floodplain	>5000–15,000[5]
5 (Oldest)	Qadirabad	Late II to Early III	Bk, Bt	Stream Terrace Remnant	>7080±90[6]

1 Based on soil morphologic features and landscape position.
2 Based on classification by Gile et al. (1966) and Sehgal and Stoops (1972).
3 Last flood of Recent Channel (M. Saddiq, personal communication, 1988).
4 Approximate date of beginning of Harappan occupation (Kenoyer 1987).
5 Based on rates of pedogenic carbonate redistribution (Gile and Grossman 1979).
6 Radiocarbon date of carbonate on the inside of a nodule from Btk horizon (Pendall and Amundson 1990b).
Source: Pendall and Amundson (1990a).

sands of years to form a carbonate nodule, the ^{14}C age could easily suggest an early Holocene, or even latest Pleistocene, age for the deposit. The relationship of the deposit (now preserved in small portions under and around the mound) to the alluvium comprising the more extensive Lower Bari Doab terrace between Pattoke and Sahiwal is not known with certainty, but they could be the same. More fieldwork and elevation data are needed to work this relationship out.

During Holocene times, the river Ravi (presumably when it occupied the abandoned channel north of Harappa) meandered around Harappa, entrenching and subsequently partially backfilling its channel. At least three meander units of differing ages could be identified on the basis of topography and soil development. The exact timing of these events is not known with certainty. The presence of significant carbonate nodule development in the oldest meander unit suggests that it is at least several thousand years old, while the presence of pottery fragments in the alluvium of the youngest unit suggests it postdates Harappa itself (Table 3.3). It appears that subsequent downcutting by the Ravi (when it occupied the abandoned channel) ultimately bypassed the meander bends around Harappa, creating a more direct route along the north of present-day Harappa. Thus, the soil/geomorphology map (Figure 3.4) and the relative age estimates (Table 3.3) suggest that Harappa was initially built on a slightly elevated landscape in a meander bend of what may have been at least a seasonally active Ravi river channel. It is difficult to determine, without more fieldwork, if the main channel of the Ravi flowed by Harappa during Harappan times. It does appear, however, that the meander bends around Harappa were essentially abandoned at some time after the Harappan occupation.

It should be noted that the "abandoned" channel of the Ravi can still receive flood waters during the summer monsoon season and that even the relatively elevated landscape around Harappa can become inundated by these floods. Thus, by no means is Harappa entirely removed from the influence of the present-day river Ravi.

Stable Isotope Studies of Pre-Harappan Soil

As discussed in the previous section, at least a portion of Harappa was built on a latest Pleistocene or early Holocene alluvial deposit. Thus, the soil that formed in this deposit was at least several thousand years old prior to burial during human occupation and should have had sufficient time to chemically reflect pre-Harappan environmental conditions.

In recent years, a search for soil properties that can be quantitatively correlated with climatic parameters has been underway. One of the most promising avenues has been the work on the stable carbon

($^{13}C/^{12}C$) and oxygen ($^{18}O/^{16}O$) isotope ratios in soil carbonate. A brief review of this work, and its significance to our work at Harappa, is given below.

Isotope ratios in a sample are reported relative to those in an internationally-accepted standard in the notation:

$$\delta(‰) = 1000\left[(\text{R sample} \div \text{R standard}) - 1\right]$$

where 'R sample' equals the isotope ratio in a sample and 'R standard' equals the isotope ratio in the standard. The standard for carbon is the Peedee belemnite (PDB) and for oxygen it is standard mean ocean water (SMOW).

Carbon isotope ratios (i.e., $\delta^{13}C$ values) in soil carbonate are determined by that of the soil CO_2 (Cerling 1984). Soil CO_2 is derived from two sources: (1) root respiration/decomposition of soil organic matter (biological) and (2) atmospheric CO_2 ($\delta^{13}C$ = –7‰). Isotopically, there are two main types of plants: (1) C_3 ($\delta^{13}C$ values ≈–27‰) and (2) C_4 ($\delta^{13}C$ values ≈–14‰) (Bender 1968; Smith and Epstein 1971). C_4 plants are mainly restricted to the tropical grasses while C_3 plants make up the remaining grasses and nearly all other plants.

If the $\delta^{13}C$ value of decomposing plant material is known, the $\delta^{13}C$ value of soil carbonate can be used to determine the proportion of CO_2 derived from biological or atmospheric sources. It has been found that the proportion is related to plant density and soil respiration rates (Amundson et al. 1989; Quade et al. 1989) and that atmospheric CO_2 only makes a significant contribution to soil CO_2 in arid regions (Cerling et al. 1989). Thus, soil carbonate can be used to distinguish between semi-arid and truly arid conditions if the $\delta^{13}C$ of biologically-produced CO_2 is known.

In regions where tropical grasses are present and the climate is at least semi-arid, plant cover is usually dense enough so that atmospheric CO_2 makes only a small contribution to total soil CO_2 (Cerling et al. 1989). Therefore, in sites where tropical grasslands or savannas are known to have existed, the $\delta^{13}C$ of soil carbonate can be used to reflect the relative proportion of C_3 to C_4 plants at the site. This is important to know in that the C_3:C_4 ratio is strongly dependent on climate, particularly temperature (Tieszen et al. 1979).

The $\delta^{18}O$ value of soil carbonate is determined by that of the soil water (Cerling 1984), which is ultimately derived from the precipitation. While factors controlling the $\delta^{18}O$ values of precipitation are very complex (Gat 1980), it has been observed that it is commonly correlated to regional temperature (Yurtsever 1975). Thus, the $\delta^{18}O$ values of soil carbonate can serve as a guide to the $\delta^{18}O$ value of past precipitation as long as possible evaporation effects are considered and the effect of soil temperature is taken into account (see Cerling 1984; Quade et al. 1989 for more detailed discussions).

During the 1987 excavations of Cemetery R37, several excellent exposures of the Qadirabad soil (Table 3.2) were made. In some locations, the profile was truncated and buried by several meters of archaeological material, while in at least one other location the upper horizons of the profile were found intact, buried by a few centimeters of archaeological material. Because the soil horizons could be traced easily throughout the cemetery, a complete profile was readily reconstructed.

Calcium carbonate nodules (i.e., *kankar*) were collected in a depth sequence from their uppermost appearance in the profile (120 cm beneath original land surface) to a depth of almost 400 cm (with the aid of a soil auger). From each soil horizon, or depth interval, samples of the bulk soil, the exterior of the nodule, and the interior of the nodule, were analyzed isotopically. In addition, sediments from the present Ravi floodplain were also analyzed (see Pendall and Amundson 1990b for more details).

The results of the carbon isotope analyses are illustrated in Figure 3.5. The carbonate nodules are formed from the dissolution of fine-grained carbonate in the alluvium and its subsequent precipitation in nodular forms. The data in Figure 3.5 illustrate that the $\delta^{13}C$ values of the nodules are distinct from fine-grained carbonate in the soil or from that of fresh river Ravi alluvium (–3.8‰). Recent work has shown that pedogenic carbonate does not inherit its $\delta^{13}C$ values from its parent material, but instead isotopically reflects the $\delta^{13}C$ values of the soil CO_2 (Amundson et al. 1989; Quade et al. 1989). Thus, the $\delta^{13}C$ values of nodules can be used to evaluate environmental conditions that existed when the soil formed. A ^{14}C age of the inner portion of a nodule of the soil yielded a ^{14}C age of 7,080±120 years BP (Beta 21520). We believe this to be a minimum age for the soil since it takes at least several thousand years to develop carbonate nodules of the size we encountered (Sehgal and Stoops 1972). Thus, the soil carbonate of the inner portions of the nodules probably reflects mainly early Holocene conditions, although a pre-Holocene age is also possible (Pendall and Amundson 1990b).

What climatic conditions do the $\delta^{13}C$ values of the carbonate reflect? Since Harappa is presently on the arid edge of the semi-arid belt (Singh et al. 1974), one question might be, were early Holocene conditions similar, or possibly more or less arid, than the present (i.e., does the carbonate contain significant percentages of atmospheric CO_2 due to a low plant density)? To evaluate this, we must know what the $\delta^{13}C$ of biologically produced CO_2 was at the time the nodules formed. We measured the $\delta^{13}C$ values of

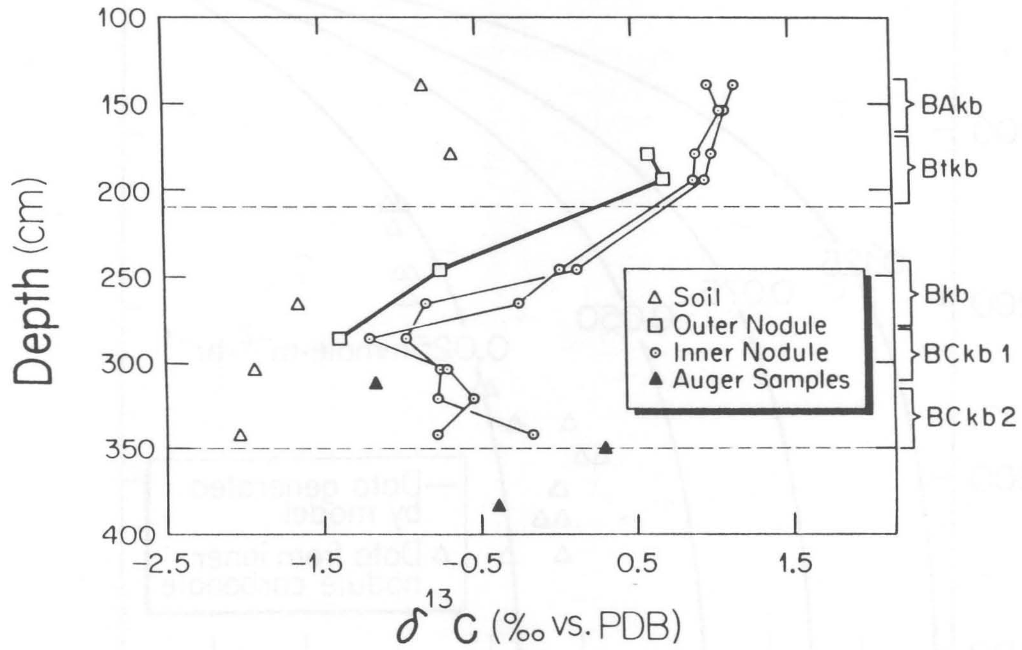

Figure 3.5: Carbon isotopic composition of carbonate in inner and outer nodule layers and disseminated in soil. BAkb and Btkb horizons sampled from profile SC3; Bkb, BCkbl, and BCkb2 horizons sampled from profile NC1. From Pendall and Amundson (1990b).

organic matter in the Ab horizons of the Qadirabad soil. The values ranged from –20 to –22‰, indicating approximately a 60% C_3 and 40% C_4 mix of plant sources. If this organic matter is representative of pre-Harappan vegetation, then the soil carbonates reflect an atmospheric CO_2 contribution of nearly 30% and a soil respiration rate representative of very arid and sparsely vegetated sites (Figure 3.6).

Soil organic is very dynamic, and the present $\delta^{13}C$ values may reflect vegetation altered by human activity and may not be representative of pre-Harappan conditions. Thus, an alternative explanation, as discussed above, can be made. If it is assumed that the site was always under at least semi-arid conditions and that it had a closed vegetative cover, the $\delta^{13}C$ values of the carbonate can be taken as representative of the C_3:C_4 plant ratio at the site. Soil carbonate $\delta^{13}C$ values are about –15‰ greater than the plants that produce CO_2 at a site (Cerling et al. 1989). Using this relationship, the $\delta^{13}C$ values of the carbonate illustrated in Figures 3.5 and 3.6 could be interpreted as having been formed in a nearly pure C_4 flora, such as a tropical grassland or savanna.

Unfortunately, with the available data, we can not distinguish between the two alternatives given above. The limiting factor in the analysis is an inadequate knowledge of the $\delta^{13}C$ of soil organic matter at the time the carbonate formed. The answer to this may lie in the nodules themselves in the form of occluded organic matter. Possible future work may be able to isolate this carbon and solve the dilemma.

The $\delta^{18}O$ values of the carbonate samples are illustrated in Figure 3.7. In contrast to the $\delta^{13}C$ values, there is virtually no difference between the isotopic composition of the fine-grained carbonate in the bulk soil and that of the nodules. The source of the carbonate in the alluvium is not known, but it may contain significant quantities that were formed in a pedogenic environment farther upstream on the Ravi.

The main interest here is whether the $\delta^{18}O$ values of innermost nodule samples reflect conditions significantly different than the present. To evaluate this, the $\delta^{18}O$ value of present-day precipitation must be known. Monitoring stations are few in South Asia. Available data suggest that the average isotopic composition of rainwater in New Delhi is –5.7‰ while that of Karachi is –4.1‰ (International Atomic Energy Agency 1960-1987). At 25°C, which is approximately the mean annual temperature of Harappa, carbonate forming from these waters should range between 22.8‰ and 24.4‰ (O'Neil et al. 1969). The $\delta^{18}O$ values of the inner nodules are slightly less than that predicted from the present rainfall for Karachi and New Delhi, assuming this temperature. We do not know if this represents a real difference or if it is due to our lack of isotopic data for regional rainfall. If real, the difference would suggest slightly cooler conditions than the present or greater rainfall out of

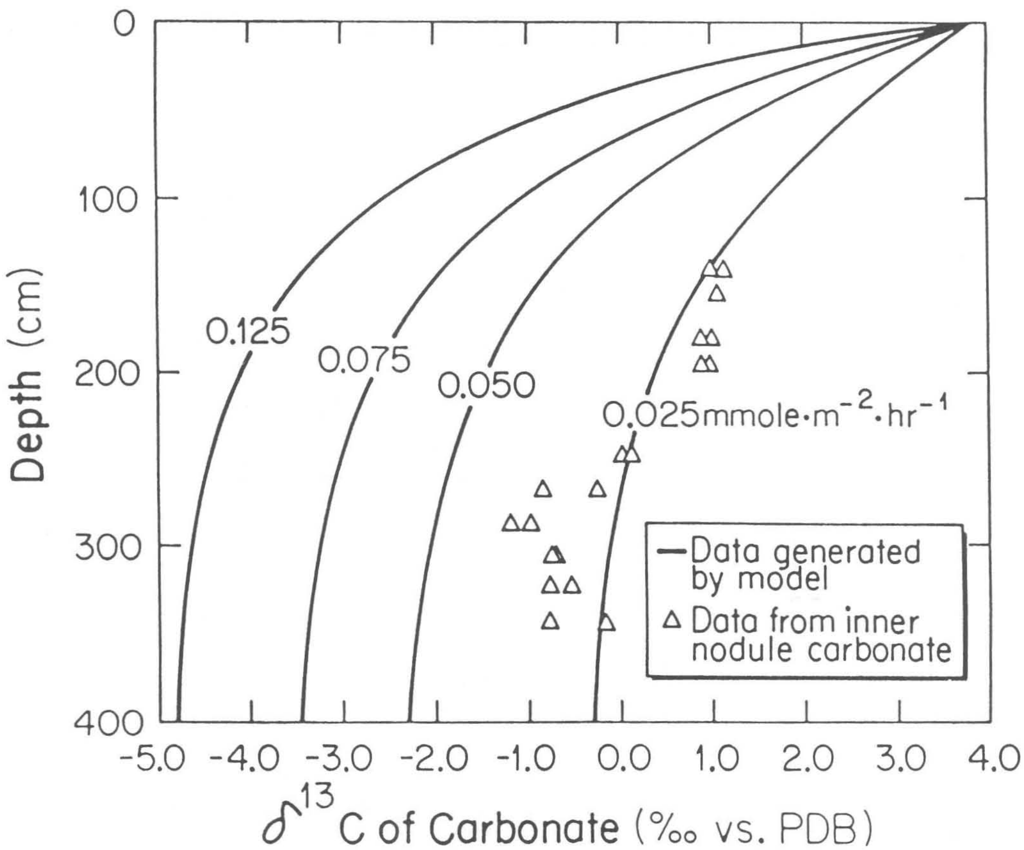

Figure 3.6: Carbon isotopic compositions of inner nodule carbonate in Qadirabad soil (triangles) compared with values calculated by the model of Quade *et al.* (1989). Variables: P = 1 atm, T = 25°C, n = 0.4, production $\delta^{13}C$ = –21.9‰, atmospheric $\delta^{13}C$ = –6.0‰, and various soil respiration rates. From Pendall and Amundson (1990b).

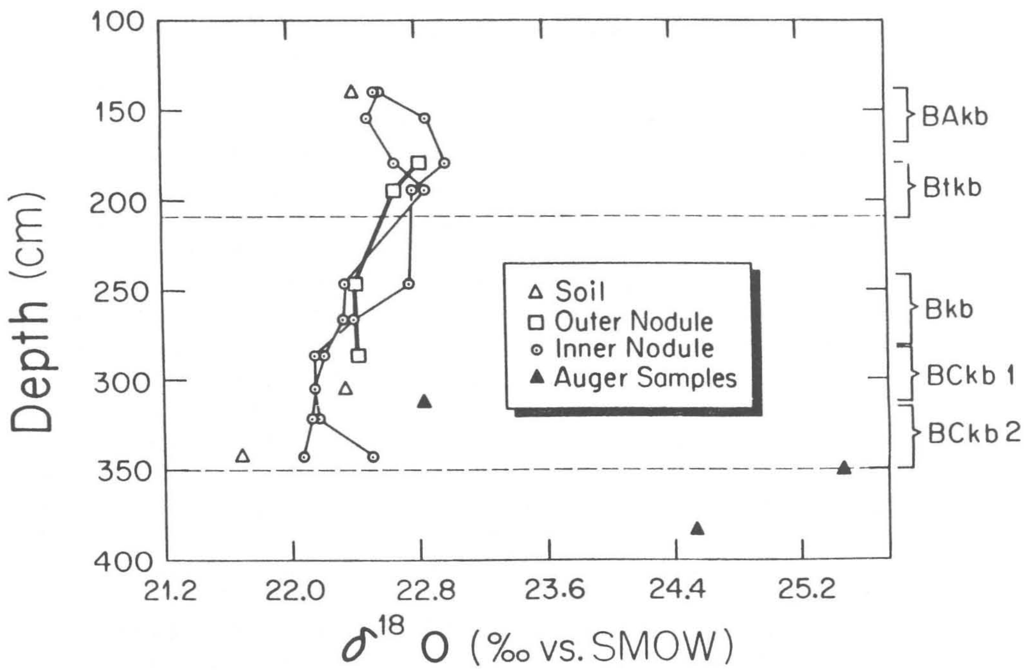

Figure 3.7: Oxygen isotopic composition of carbonate in inner and outer nodule layers and disseminated in soil. From Pendall and Amundson (1990b).

storm fronts that reached Harappa in the past. The latter would certainly seem reasonable based on estimates of early Holocene monsoon intensity for South Asia (COHMAP Members 1988). Alternatively, the carbonates may have formed at a higher temperature than 25°C (for example, during the warm, summer monsoon season). Assuming a soil temperature of 30°C, carbonate forming from present rainwater would range between 21.7 and 23.3‰, which agrees well with the measured values in Figure 3.7. We strongly emphasize that a better understanding of the isotopic composition of present rainfall at Harappa is needed before this issue can be resolved.

Summary

The purpose of this paper was to consolidate previous climatic and geologic research pertinent to Harappa in a manner that would provide a framework for our recent pedological studies, as well as provide a better means of understanding the environmental context of Harappa. We think that it would be fair to conclude that a very intriguing, but sketchy, picture of the environmental and geological history of Harappa emerges from this exercise. The other point that emerges is that an array of important problems and topics remains to be studied and understood. It should be apparent to interested earth scientists that a wealth of exciting research problems are available for years to come if the environmental context of Harappa, and the Indus civilization, is to be understood.

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Cover art: Bowl on Stand H88-1002/192-17 associated with Burial 194a
in Harappan Phase Cemetery (see Figure 13.18).

4

Urban Process in the Indus Tradition: A Preliminary Model from Harappa

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Excavations on two of the major mounds at Harappa have revealed traces of an early settlement, a transitional phase of development, and several phases of full urban and post-urban occupation. Although there is a continuity of occupation, evidence for settlement growth and changes in organization reveal a dynamic process of city development. The segregation of specific crafts and occupations, the availibility of new and exotic raw materials, the construction of massive perimeter walls and entrances, and the maintenance of civic structures provide a new perspective on the nature of an Indus city. A preliminary model is presented for the development of Harappa as a city in the wider context of the Indus Tradition.

In studying the earliest urban settlements of South Asia, we do not have written documents that describe the structural and social organization of a city. Consequently, our understanding of the urban process is often quite sketchy. The extensive archaeological excavations of the large urban centers of Harappa and Mohenjo-daro (Figure 4.1), carried out in the 1920s and 1930s, provided a remarkable glimpse of a previously unknown civilization, but little was discovered about its origin, growth, and internal organization. Subsequent excavations at these and other third millennium sites in the region have been undertaken to obtain additional details on the urban phenomenon of the Indus Tradition.

The observations and interpretations from these excavations, however, have been based on general impressions and, with a few exceptions, were not supported by the publication of detailed stratigraphic sections, plans, or artifact distribution analyses. As a result, it is difficult to critically assess many of the initial interpretations. Because of these problems, new excavations are needed at all of the previously excavated sites. Through the cooperative agreement between the Government of Pakistan, Department of Archaeology and Museums, and the University of California, Berkeley, it has been possible to open new excavations at the important site of Harappa (District Sahiwal, Punjab, Pakistan: Figure 4.2).

Major objectives in these recent excavations at Harappa have been to collect data that were overlooked in previous large scale horizontal excavations, specifically those data relating to the growth and dynamics of this early urban center. By combining the new information with general observations from extensive horizontal exposures made in the past, it is possible to better understand the location of Harappa, why and how the settlement grew and expanded, and how the city was organized.

In this paper I present a brief summary of the findings from the first five years of the current excavations at Harappa and a preliminary model for conceptualizing the growth of Harappa as a city. The value of such a model is that it allows more specific comparisons within the Indus region and West Asia and helps to define and direct future research.

Harappa as Known from Previous Excavations

Prior to the current excavations at Harappa, major research at the site was conducted by M.S. Vats from 1926-1934 (1928-29, 1940), K.N. Shastri during the late

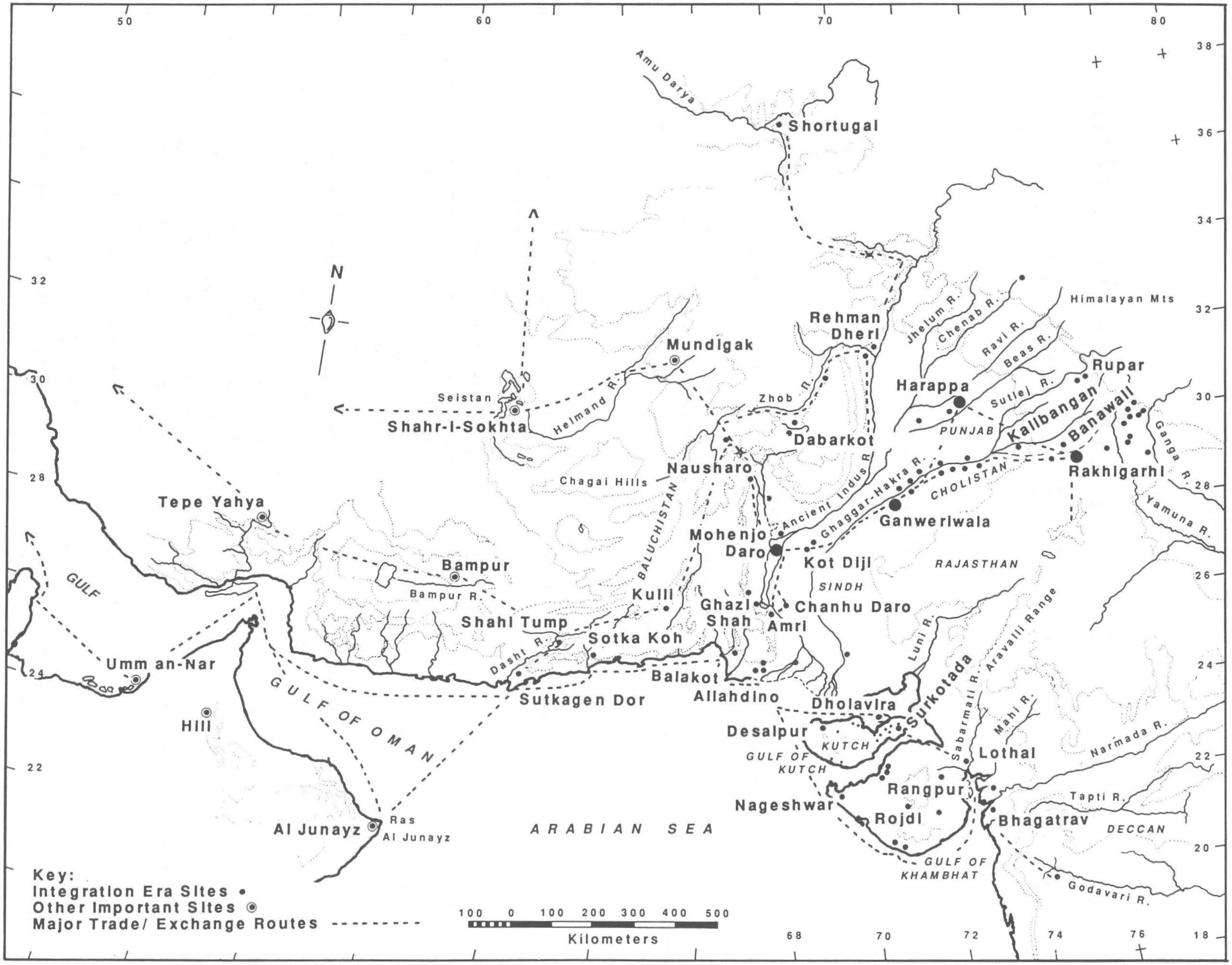

Figure 4.1: Map showing major sites and interaction networks of the Indus Tradition, Integration Era, Harappan Phase.

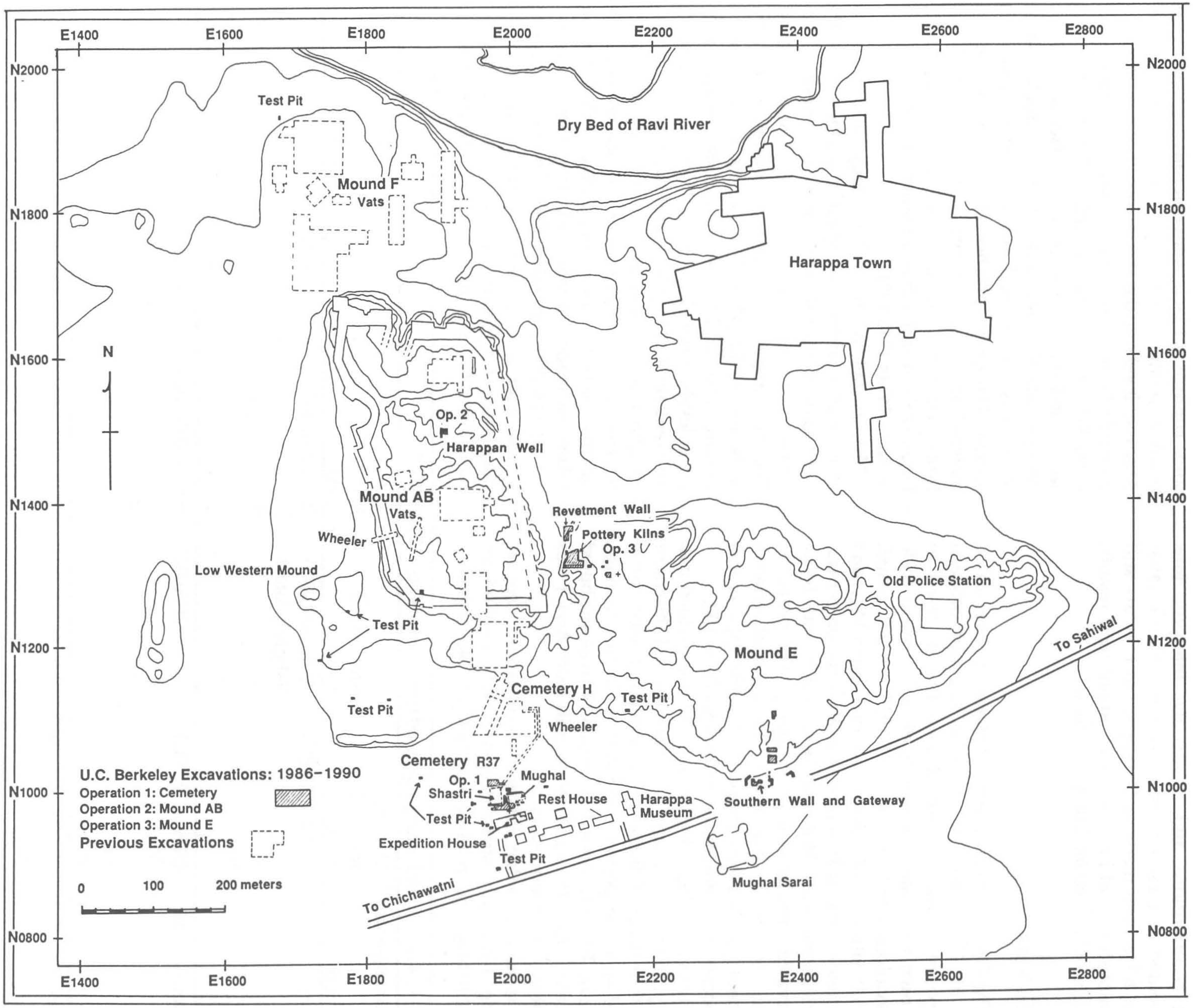

Figure 4.2: Harappa 1990 site plan showing extent of excavations.

1930s (unpublished), R.E.M. Wheeler in 1946 (1947), and M.R. Mughal in 1966 (1968). In the context of this presentation, it is important to summarize the important contributions and clarify the interpretations presented by these earlier excavators. Other excavations have been made at Harappa, but they are still unpublished, and little is known about their results. (See Possehl, Chapter 2 in this volume.)

M.S. Vats

The first major excavations at Harappa were carried out by M.S. Vats. He (and his superior officers) proposed an internal chronology of the site based on his own work and the results of earlier small scale excavations conducted in 1921-1925 by D.R. Sahni. The classification of artifacts, internal chronology, and absolute dating of Harappa were all based on general correlations with Mohenjo-daro, which was being excavated simultaneously. Although the proposed dates are no longer valid, the internal relative chronology that was proposed for Harappa is still important for comparative purposes (Table 4.1).

The overall chronology of the site was divided into Early, Intermediate, and Late periods, and the major levels or strata of discrete excavation units were correlated to these period designations. In this manner, stratum III from Mound F, Trench IV, was attributed to Late Period III, while stratum III from Area J was attributed to Intermediate I.

It is quite clear that Vats and his colleagues were not using a carefully structured systematic method for establishing the relative chronology. Nevertheless, general correlations were made on the basis of an extensive knowledge of artifact types and careful observations of artifacts found in the major levels. In some contexts artifacts were carefully collected using small excavation knives and sieves (Vats 1940:58). Absolute levels of the strata were not considered as particularly relevant, and in several contexts Vats (1940:135) emphasizes that, although walls or artifacts were found at low levels, they are in fact derived from later periods. Vats also was concerned with the mixing of artifacts due to brick robber trenches and to the ancient Harappan practice of using older cultural material as filling in floors, foundations, and platforms. He paid careful attention to the mixing of larger seals in strata that contained the tiny seals and sealings (Vats 1940:120).

The overall relative chronology was based on general observations of specific artifact types that came to be identified as chronological markers. These artifacts included ceramics, figurines, and seal types. The most important in this discussion are the "tiny seals and sealings" and terracotta toy figurines of archaic type, which were invariably found in the lower levels of the excavations (Figure 4.3). In order to differentiate the "tiny seals and sealings" from actual intaglio seals and seal impressions, they here will be referred to as "steatite and faience tokens." The steatite tokens are incised in positive while the faience tokens are made in a mold or bear seal impressions.

Vats (1940:3) estimated that the site of Harappa spread over an area some 3.5 miles "in circuit." If calculated as a square, this would enclose approximately 198 hectares or as a circle, 252 hectares. Our

Table 4.1. General stratigraphy adapted from Vats (1940:9-10).*

Mohenjo-daro** Period	Harappa Mound F Strata	Mound AB Strata	Area J Strata	Area G Strata	Cemetery H Strata
Late	(2750-3050 BC)	(2750-3050 BC)	(2850-3050 BC)	(2700-2800 BC)	(2000-2500 BC)
I	I	I(slightly later)	I	I	I
II	II	II	II	II	II
III	III	III			
(IV)		IV			
Intermediate	(3050-3500 BC)	(before 3050 BC)	(before 3050 BC)	(3250 BC)	
I	IV	V	III	III	
II	V	VI	IV		
III	VI				
(IV)	VII				
Early	(1st 1/2 4th mil.)				
I	VIII				
II					
III					

*Dates are those quoted by Vats (1940:9-10).

**This periodization for Mohenjo-daro is based on Marshall (1931) but modifications were proposed by Mackay (1938:xiv).

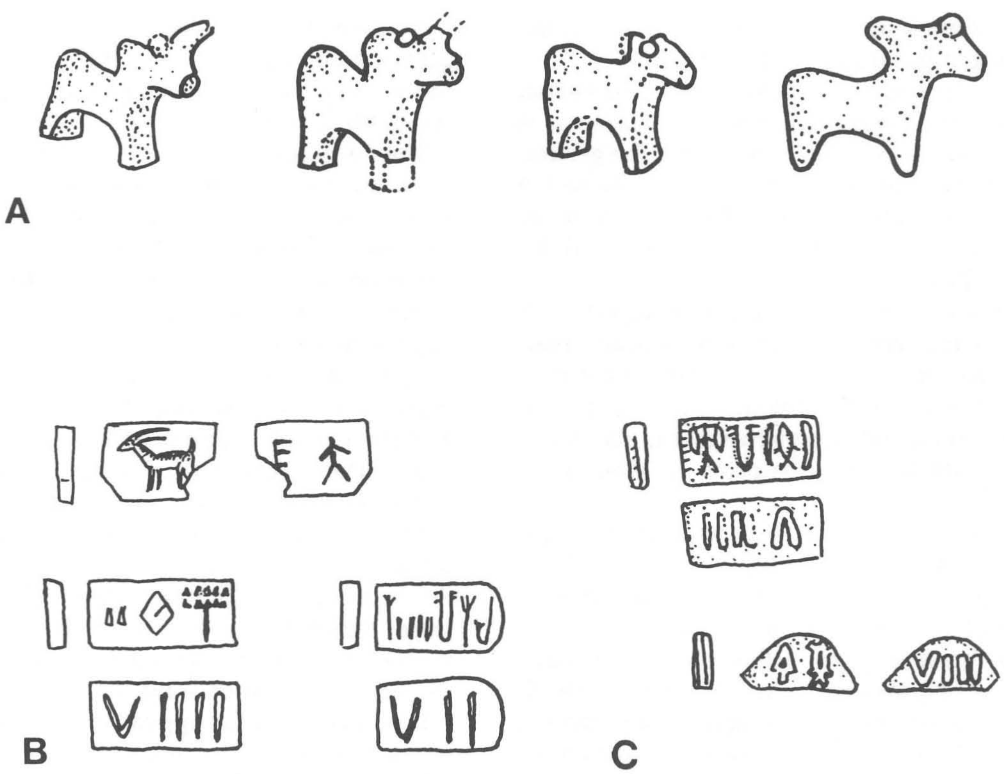

Figure 4.3: Harappa Figurines and Tokens: A. Examples of figurines with legs joined (from Vats 1940:Plate LXXIX, 61, 62, 63, 64); B. Examples of incised steatite tokens, Harappa 1990, Period 3B; C. Examples of faience tokens, Harappa 1990, Period 3B. (See Figures 13.44 and 13.46 in this volume.)

current estimate is that the site was at least 150 hectares in area (Dales and Kenoyer 1989a).

Vats and his predecessors excavated in five major areas: Mound F in the northwest; Mound AB, Area J, and Area H (all to the south of Mound F); and Area G on the southeastern perimeter of the mounded areas (Figure 4.2). Mound E and modern Harappa town were examined, but no major excavations were conducted in those areas.

Natural soil and the water table were reached on Mound F in Trench I. There, the lowest level of Harappan occupation consisted of a drain made of baked brick built on top of undisturbed soil (3 feet thick), "and then followed by a deposit of sand which has been cut through for another 7 ft. where the level of sub-soil water has been reached" at a depth of 35 feet below surface (Vats 1940:97). Two other deep diggings were made, one in Trench IV of Mound F and the other in Area J to the south of Mound AB. Although Vats did not reach natural soil or the water table in these trenches, he did note that the cultural material was Harappan. The precise elevations of these deep diggings have not been calculated due to the absence of datum points and the fact that the present surface is totally modified.

In all three of these trenches, Vats notes the presence of steatite and faience tokens in the lower levels. In the lowest levels he notes the presence of archaic terracotta bull figurines (Vats 1940: Pl. LXXXIX, 62) (Figure 4.3), which have the two front and two back legs joined together. In later figurines all four legs are separate.

On the basis of these artifacts and similarities in ceramics, Vats suggests that the occupations in both Area J and Mound F were contemporaneous and represent the earliest habitation of the city, while the massive height of Mound AB represents a later period of city growth that was accompanied by construction of extensive mud-brick fillings or foundations. These mud-brick structures are visible around the entire circumference of Mound AB, and Vats (1940:7) suggested that they were constructed primarily to protect the city from floods.

In terms of city layout and organization, Vats was greatly hampered by the fact that most Harappan baked brick structures had been removed by brick robbing. This disturbance extended up to two meters below the surface in most areas, and some tunneling reached deep inside the mound. Consequently, few complete structures were identified, although Vats

does provide some interesting information about the architecture and organization of the city.

Based on Vats's report, it is possible to confirm that the overall layout of specific portions of Harappa is quite similar to that seen at Mohenjo-daro. The general layout of the streets and alleyways is best referred to as an "irregular net plan" (Jansen 1978:69-74) rather than as the more rigid "grid plan" described by Wheeler (1947, 1968).

Most houses were made from baked brick, although Vats (1940:163) does note mud-brick houses and platforms as well as remains of charcoal from what may have been reed and thatch hutments. Evidence for the use of bamboo and wood superstructures is also noted from the area with bathing platforms on Mound AB (Vats 1940:172).

In the total area excavated by Vats and his predecessors, only six wells were discovered (Vats 1940:13). Four of these are on Mound F, one large double ring well on Mound AB, and one small well in Area G. Vats suggests that one of the wells on Mound F was a semi-private or neighborhood well (House 1, Trench VI), while the others were accessible to the general public. One additional well was found in our recent excavations on Mound AB (Dales and Kenoyer 1989a).

Except for the relatively small number of identified wells, the architectural layout and construction of houses are generally comparable to that seen in the better preserved structures at Mohenjo-daro.

At Mohenjo-daro three basic categories of architectural units have been defined by Jansen (1980, 1984), although there are significant variations both in terms of scale and complexity within each group. The first category includes private houses that are oriented towards a central space, where direct access from the street is protected by an entrance that blocks the view of the interior. The central space provides access to rooms and bathing areas that are not always connected directly to each other. Groups of habitations form a kind of neighborhood that is often associated with one or more private wells. At Harappa the series of identical houses found on Mound F represents this type of neighborhood, and there is a single well just to the south of these structures.

A second category of habitation units is seen in large houses surrounded by smaller units. This pattern results in a complex with many different sizes of rooms and access routes. The outer units may reflect habitation-cum-workshops for various service groups attached to the central larger house. Possible examples of this are found at Harappa on both Mound F and Mound AB.

The third group includes large public structures that have an open access or provide a thoroughfare from one area of the site to another. Large open court yards, the "Great Bath" of Mohenjo-daro, and huge structures such as the so-called granaries at both Mohenjo-daro and Harappa are examples of such public structures.

The "granary" found on Mound F at Harappa has been the focus of much attention, although in fact there is no indication of its precise function (Fentress 1984:89-98). Its massive foundation was clearly made to support a substantial superstructure, but there is no adequate explanation of the so-called air ducts that appear to have run beneath the floor. Whatever its original use, this structure (and other large scale works) would have required considerable expense and labor mobilization to construct.

Important features of both Mohenjo-daro and Harappa were carefully designed and generally well maintained drainage systems. Wells and bathing platforms were lined with bricks, and small drains carried waste water away from the wells or habitation areas to larger street drains. The street drains were equipped with sump pits and the streets with garbage bins for the accumulation of solid waste. Many of the sump pits or garbage bins appear to have been made from old or broken storage jars. At Harappa, Vats (1940:174-175) has identified many jars in streets as being "post cremation urns." In one area of Mound AB he reports 54 broken large storage jars in a street lined up at the edge of a series of buildings. All of the jars were broken, and in many cases they were stacked three high. The contents Vats describes are typical of the garbage found in sump pits. In reviewing his descriptions of these "post cremation urns," it appears that all of them should be reclassified as sump pits or garbage bins, a position that is also held by Wheeler (1947).

Accumulations of refuse in the garbage bins and elsewhere inside the settlement were presumably collected and dumped outside or in abandoned areas of the city. The drainage system within the site insured that waste water did not seep back down into the wells, but was directed to the edge of the settlement. Along the western edge of Mound AB and in the area of Cemeteries H and R37, there is evidence for extensive city dumps. Occasional structures and craft indicators suggest that at certain times specific craft activities were carried out in these peripheral zones (Dales and Kenoyer 1989a; Chapter 13 in this volume; and, for Mohenjo-daro, Pracchia et al. 1985).

The distribution of specific types of artifacts or craft activity areas throughout the site was not addressed specifically by Vats. The association of circular working platforms, furnaces, kilns, and the so-called granary in Mound F, however, was thought to indicate that this area of the city was for industrial use and storage as opposed to elite habitation. Of interest is the fact that seals were found in all of the excavated areas

and hoards of jewelry and copper-based implements were found in the vicinity of the kiln and working platform areas of Mound F. These hoards have been interpreted as stock piles maintained by artisans, rather than as the hidden wealth of private individuals. Unfortunately there is little detailed documentation of the location of specific artifacts and manufacturing areas, and it is impossible to determine their precise association. For example, the widespread distribution of seals may well be the result of post-depositional disturbances such as erosion and foundation filling rather than an accurate representation of where they were being used.

In sum, upon careful review of the published record, the excavations by Vats do not provide the kind or quality of evidence necessary to demonstrate whether or not craft activities were being carried out in segregated areas of the city, even though this has been assumed by many scholars (e.g., Wheeler 1947, 1968; Piggott 1950).

R.E.M. Wheeler

Wheeler (1947) opened the second major excavation of the inhabited areas of Harappa in 1946. In addition to his concern about the stratigraphic relationship between cemetery areas H and R37, his goals were to ascertain the presence or absence of a city wall on Mound AB and its relationship to the general stratigraphy of the site as proposed by Vats (1940:64).

Wheeler made ten trenches at isolated points around the southern, western, and northern edges of Mound AB. The largest of these trenches reached to natural soil and cut through a massive mud-brick structure that formed the western edge of the mound. In all of the other isolated and unconnected test trenches, he encountered massive structures of mud-brick and remnants of baked brick facings that were invariably on the outside surface of the mud-brick structures. The baked brick facings were between one and two meters thick and were generally battered, slanting up towards the top of the mound.

In most of these trenches more than one phase of construction was identified (Wheeler 1947: 64-65). The initial building of the mud-brick rampart was followed by extensive erosion and weathering. Subsequently, the structure was rebuilt and reinforced with mud-brick and/or baked brick facings. Overall, three major periods of construction were identified. All of these appear to fall within the Harappan occupation, although Wheeler does not specifically correlate his periods with the sequence established by Vats.

In one of the trenches along the western edge of the mound, Wheeler identified a large concave area with terraces of mud-brick and scattered baked brick walls that he interpreted as a re-entrant with three gateways. He suggested that these gateways were part of an elaborate ceremonial or ritual entry to the city rather than for defensive purposes (Wheeler 1947:74). He also identified another re-entrant on the northern edge of Mound AB.

In compiling his final drawings, Wheeler had all of the mud-brick structures joined with straight dotted lines, and irregularities were squared off and made into towers. The end result of this interpretative drawing is a massive fortification with well-defined square towers or bastions and elaborate gateways on the west as well as a possible gateway on the north (Figure 4.4). (As an aside, it is interesting to note that most mud-brick fortifications of the historical period in northwestern South Asia have rounded rather than squared towers or bastions to avoid massive erosion during the monsoon.)

Careful examination of the eroding section of the massive mud-brick rampart on the west side of Mound AB, as it exists today, and comparison with the section drawing published by Wheeler (1947: Plate XXII) reveal that here, too, Wheeler provided a relatively generalized interpretation of the stratigraphy rather than accurate documentation. Without further excavations, such interpretation should be considered only as a working hypothesis. Although Wheeler established the presence of massive mud-brick structures along the edges of Mound AB, it is not clear if they functioned as revetments or if they were indeed free standing at the top. Most importantly, it is unclear if they represent a single phase of construction that encircled the entire mound or if they were the result of numerous different building episodes.

Although Wheeler's excavations did not provide any new information regarding the relative chronology of the different mounds, in his deep section he found Early Harappan pottery (as defined by Mughal 1970) in two levels that were inside and below the mud-brick structure and just above natural soil (Wheeler 1947: 66; here, Figure 4.5). During our recent surface surveys of the site we discovered numerous small Early Harappan sherds on top of Wheeler's excavation dumps. These sherds could indicate the presence of Early Harappan deposits all along the western edge of Mound AB or could derive from foundation fill that the Harappans themselves dug from Early Harappan deposits.

A careful reading of Wheeler's description of layers 26A to 30 is important since it our only record of these strata (Wheeler 1947:66, Pl. XXII; here, Figure 4.5).

- Layers 27, 29 and 30 consist of "alluvial mud containing only a few sherds, mostly of pin head size and in some cases in root-holes".

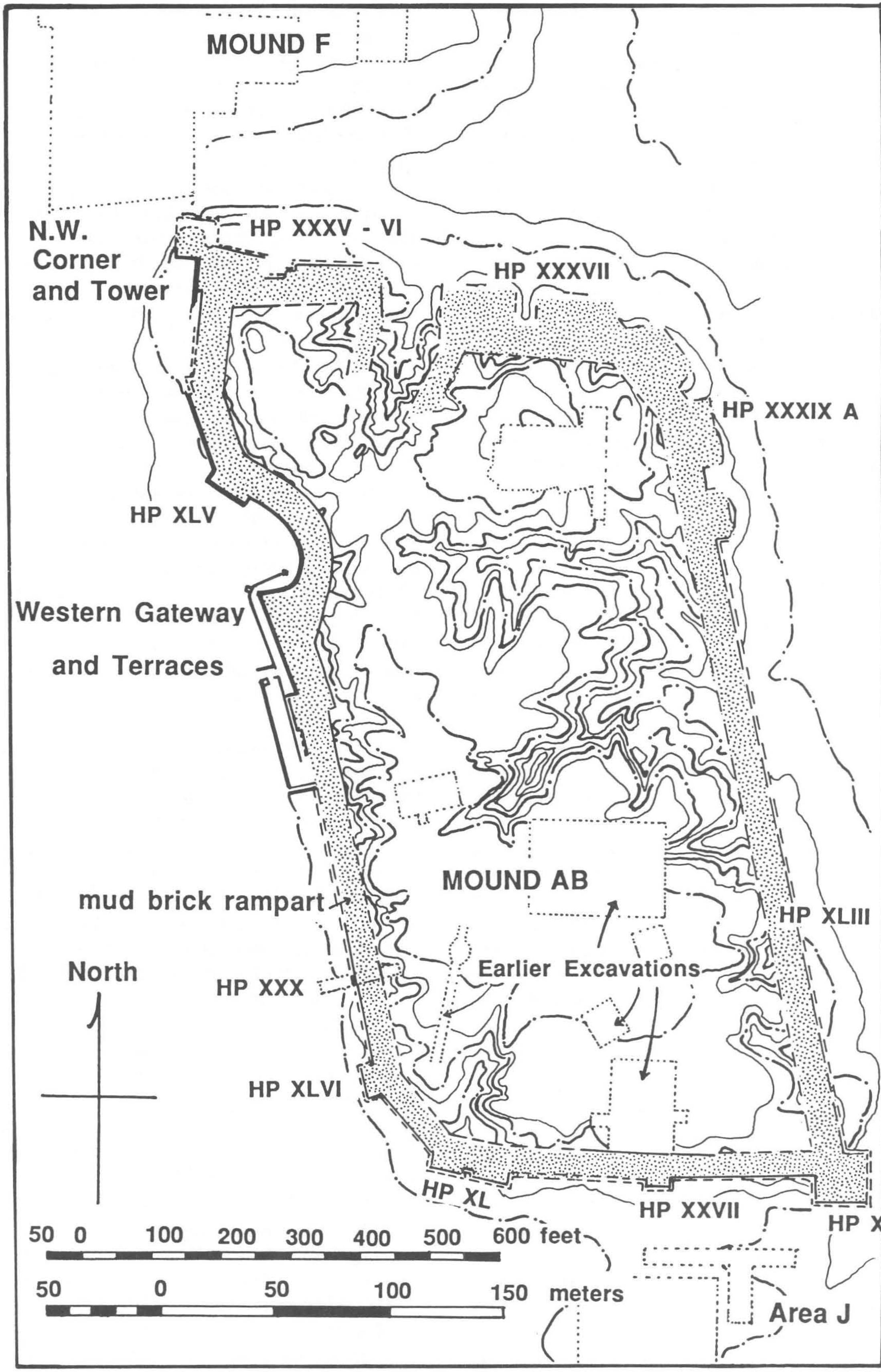

Figure 4.4: Plan of Mound AB; redrawn from Wheeler (1947:Plate XV).

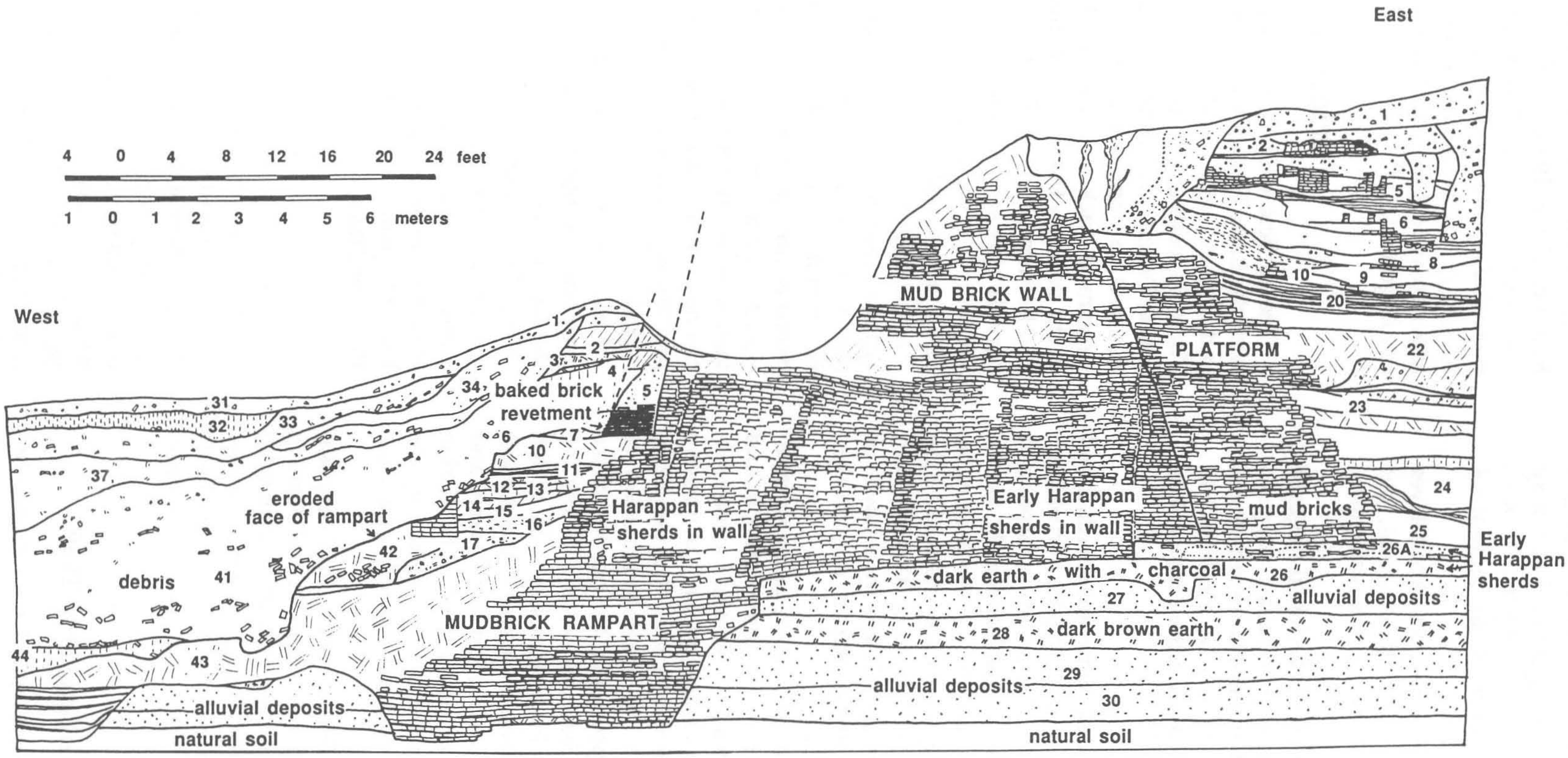

Figure 4.5: Detail of section through the mud-brick rampart, Mound AB; redrawn from Wheeler (1947:Plate XXII).

- Layer 28 was also alluvial in nature but is a darker "earthy texture, suggesting that it may have been ploughed and sown; it was, however, similarly deficient in significant pottery."
- Layer 26 is described as an occupation layer comprised of dark earth with charcoal, but there is no report of mud-brick structures, hearths, or floors.
- Layer 26A is associated with the initial stages of rampart construction, and Wheeler suggests that the presence of five non-Harappan sherds (Early Harappan types) can be attributed to digging into Layer 26 during the construction of the rampart.

Wheeler also points out that numerous sherds found in the mortar of the core of the rampart derive from Layer 26. In contrast, most of the sherds incorporated in the outer face of the rampart are definitely associated with the Harappan culture. In conclusion, he suggests that "the building of the defences marked the first impact of the Harappa culture on this site, and that the builders were preceded here by a town- or village-occupation representing a variant or even alien culture" (Wheeler 1947:93).

Mughal (1970:127-130 and personal communication) does not agree with Wheeler's interpretation and proposes that layers 26 and 26A were in fact occupation deposits and that the earliest part of the massive mud-brick structure was constructed by the Early Harappan settlers. Based on a reinterpretation of Wheeler's section he proposes that the portion of the mud-brick structure, the base of which is below the top of Layer 26A, is Early Harappan. Layer 26, which extends under the wall, would represent the earliest settlement prior to the construction of the wall, and Layer 26A would represent the build up of habitation debris inside the wall. Subsequent rebuilding by the Harappans would have eventually incorporated the Early Harappan structure.

It has not yet been possible to test Mughal's hypothesis; this would require the re-excavation and cleaning of Wheeler's section. However, as will be discussed below, most of the Early Harappan levels under Mound AB may have been eroded from the Early Harappan settlement discovered to the east, beneath Mound E.

U. C. Berkeley Expedition, 1986-1990

Current excavations at Harappa have included test trenches and horizontal exposures on Mound F, Mound AB, the Low Western Mound, the cemetery areas (near Areas H and R37), Mound E and a small test pit on the Old Police Station Mound (Dales and Kenoyer 1989a, 1989b, 1990, 1992; Chapter 13 in this volume) (Figure 4.2). These various excavations have provided significant new information that requires a revised periodization and absolute chronology as well as a new model for understanding the growth of the city (Figures 4.6 and 4.7).

Periodization

The earliest evidence for habitation is associated with the Early Harappan culture (Mughal 1970, 1990) and is found only on Mound E (Figures 4.6 and 4.7). These deposits can be sub-divided into two groups of strata; Period 1 refers to the deposits that were accumulated on natural soil prior to the construction of large mud-brick revetment walls, and Period 2 refers to the deposits that built up after the revetment walls had been constructed. The transition between the two periods appears gradual, but since the analysis is not yet complete, such statements must be understood as being provisional.

In the upper levels of the Period 2 deposits there is again a gradual transition to Period 3 which is generally referred to as the "Harappan culture." Due to the fact that there is no distinct hiatus or break, Period 3 deposits are generally defined by the presence of baked brick architecture and the entire range of artifacts associated with the Harappan phase. Period 3 can be divided into three sub-periods on the basis of preliminary correlations with the earlier excavation reports.

Period 4 is a transitional phase following the Harappan occupation, and Period 5 corresponds to the Late Harappan (Cemetery H culture) occupation of the site. Period 4 and 5 occupation levels are too fragmentary to discuss in any detail at this time. Subsequent occupations of the site during the Early Historic, Medieval, and Historic Periods also have not been adequately explored, but will eventually fit into this periodization (Table 4.2).

Chronology

At the present time, a total of 33 carbon samples from the recent excavations at Harappa have been dated (Figures 4.8a and 4.8b and Table 4.3), and additional samples are still being processed. The earliest date comes from a hearth of Period 1 (Early Harappan) situated just above natural soil. This sample date is calibrated to 3338, 3213, or 3203 BC (CALIB program, Stuiver and Reimer 1986; Possehl 1990b).

Period 2 dates are from upper stratigraphic levels, between one and two meters higher than the hearth of Period 1. These calibrated dates range from 2470 to

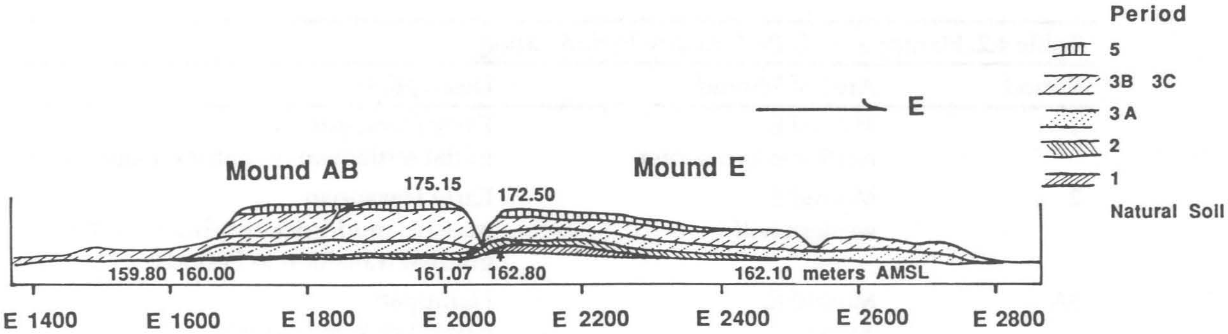

Figure 4.6: Harappa: Reconstructed East-West section through Mounds AB and E, facing north.

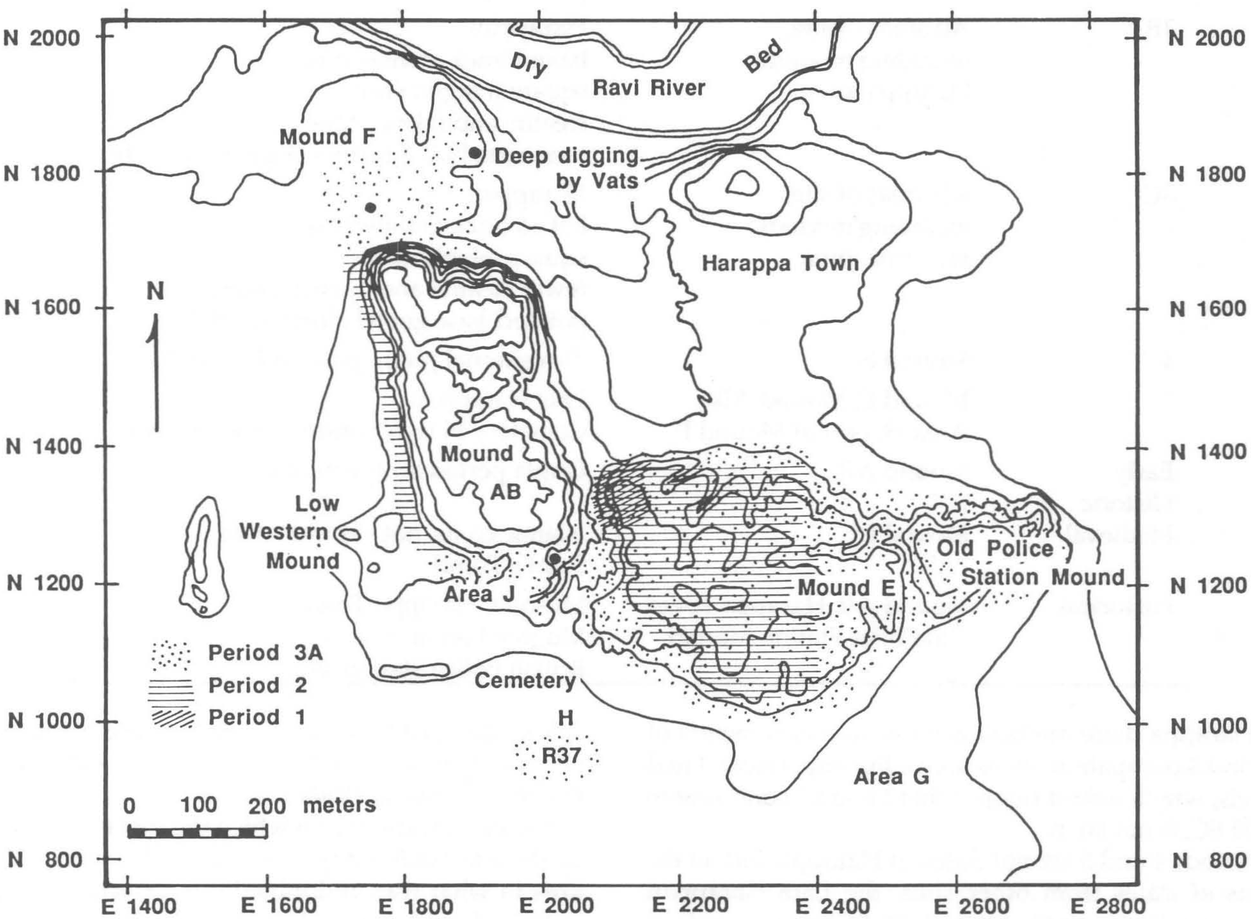

Figure 4.7: Harappa: Map showing model for extent of occupation in different periods.

2405 BC (CALIB) and overlap with the dates of the following Period 3, which range from 2913 to 2047 BC.

Based on dates from other major sites, the Harappan phase is currently thought to begin between 2700 and 2500 BC in the core regions of the Indus river valley, the Ghaggar-Hakra river valley, and Gujarat (Possehl 1990a; Possehl and Rissman 1991; Shaffer 1991). The date 2600 BC is now considered to mark the approximate beginning of the major integration of urban polities, the use of writing, weights, Harappan type ceramic designs, etc.

Dates from undisturbed hearths and kilns in the middle of the Period 3 stratigraphic sequence suggest a mid-range of 2293 BC and 2047 BC (Figure 4.8b). Some scholars feel that this urban phase is short lived and ends by 2100 or 2000 BC (Shaffer 1991). However,

Table 4.2. Harappa 1991: Preliminary Periodization.

Period	Area of Mound	Description
1	Mound E northwestern corner	Early Harappan initial settlement on natural plain surface
2	Mound E western half	Early Harappan massive mud-brick revetment walls, gradual transition to Period 3
3A	Mound E, Area J, Mound F	Harappan baked brick architecture, square intaglio seals terracotta bull figurines (legs joined), painted pottery (black on red slip)
3B	All areas of site, including modern Harappa town	Harappan baked brick architecture, square intaglio seals steatite and faience tokens, terracotta bull figurines (legs separated)
3C	All areas of site, including modern Harappa town	Harappan baked brick architecture, square intaglio seals fewer steatite and faience tokens, pointed-base goblets (final levels)
4	Mound E	Transitional phase prior to Period 5
5	Mound E, Mound AB, Area H, part of Mound F	Late Harappan Cemetery H style ceramics and artifacts
Early Historic	Mound AB	Gupta period sculpture, etc.
Medieval	Mound E	Islamic coins, not yet identified Saint's Tomb
Historical	Mound AB, Harappa Town Old Police Station Mound	Mosque, Harappa Town Mughal Fort and Serai British Police Station, etc.

at Harappa there are between one and two meters of Period 3 occupation levels above the uppermost dated levels, which would suggest that Period 3 continues to 1900 BC, if not later.

Periods 4 and 5 are not dated at Harappa, but on the basis of dates from other sites, the Late Harappan phase continues until at least 1500 BC in most regions and possibly as late as 1000 BC in the Gangetic area (Kenoyer 1991b; Shaffer 1991; Possehl and Rissman 1991).

Natural Plain Surface in Antiquity

The local topography and vegetation was probably quite similar to that seen along the river Ravi today and well documented since the time of Alexander the Great. This region was renowned for its thick marshy forests and flood plain covered with semi-arid shrubs and trees; *farash* (*Tamarix orientalis*), *karil* (*Capparis aphya*), *wan* (*Vitex negundo*), *jand* (*Prosopis spicigera*), *ber* (*Zizyphus jujube*) and wild grasses such as *sarr* (*Saccharum munja*) (Vats 1940:4-5).

The natural surface on which the earliest inhabitants at the site settled appears to have been an elevated area in what was undoubtedly a terraced river plain with ox-bow lakes and scattered dry river channels (Figure 4.2; also Amundson and Pendall, Chapter 3 in this volume). The presence of vegetation is suggested by numerous root casts visible in the natural soil. Some of these plants were undoubtedly present before the arrival of the earliest settlers, and they continued to grow in the midst of the settlement as is suggested by the presence of tiny pot sherds, ash, and red burned soil found in the root casts. In this context the term "natural soil" refers to a massive deposit of fine silty loam that in the upper portions has traces of root casts and tiny pieces of ash and red burnt soil and occasional sherds. In the lower levels it is totally sterile of

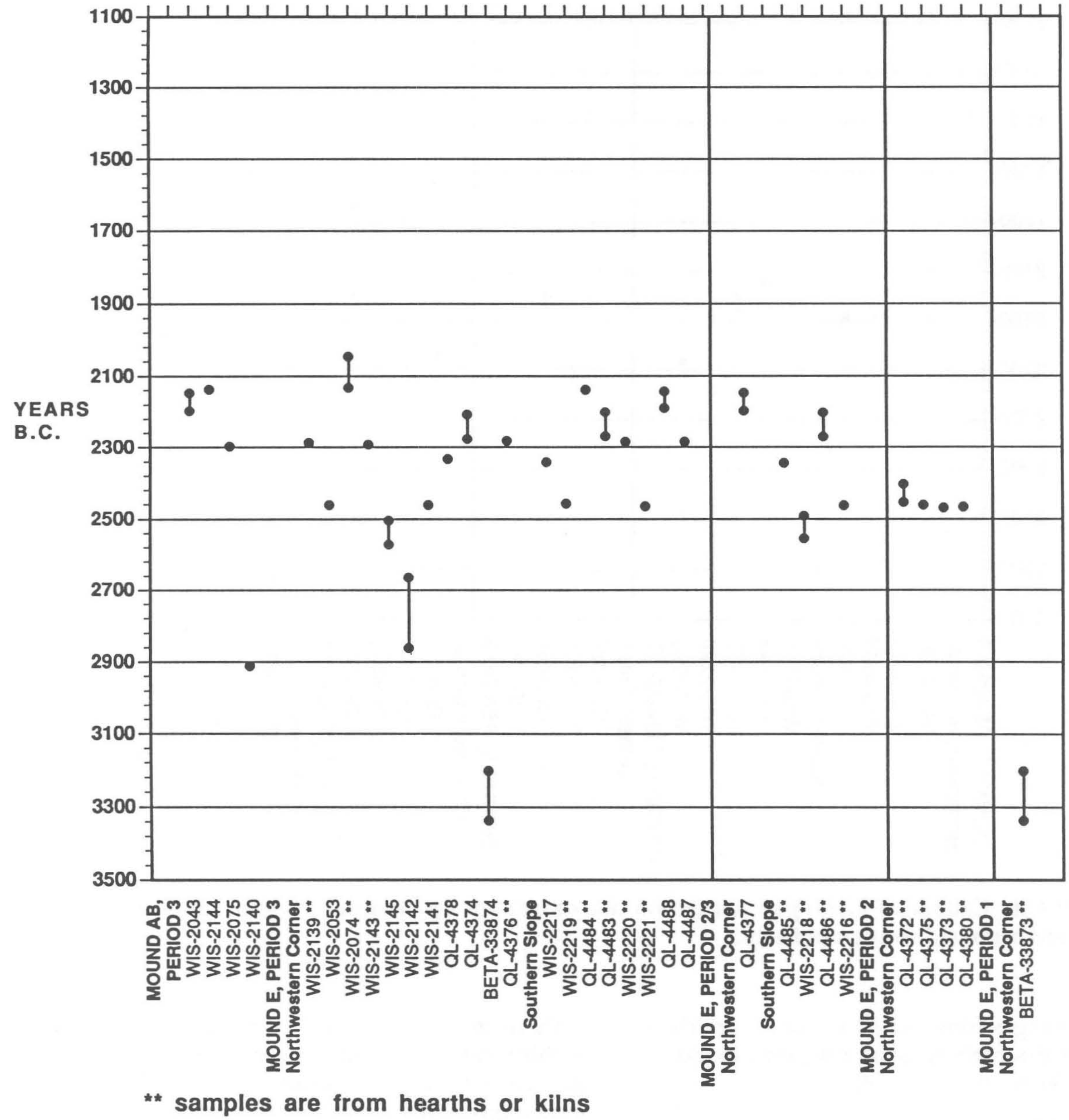

Figure 4.8a: Calibrated Harappa radiocarbon determinations arranged stratigraphically.

cultural remains and often overlies a massive clay deposit which has been identified by sedimentologists as the Qadirabad Formation. This is a late Pleistocene/ Holocene alluvial deposit, and calcite nodules from this deposit have been dated to 7080±120 BP (Pendall and Amundson 1990b, Amundson and Pendall, Chapter 3 in this volume).

The highest point of natural soil found to date is sealed beneath the earliest settlement at the north-western corner of Mound E (N1313, E2083). This elevation ranges from 162.80 m AMSL to 162.60 m AMSL. Three meters to the west there is a rapid drop in elevation (to 162.08) and then a gradual slope reaching as low as 159.80 m AMSL some 349 m to the west. A similar slope with some slight disconformities has been traced approximately 325 m to the east below the southern edge of Mound E. In this area the natural soil ranges from 162.07 to 162.15, and 162.45 m AMSL.

The topography along the major north-south section is not as easy to define, because there appears to have been a major depression just to the south of Mound E. This depression may have been scoured out during or after the Early Harappan occupation, because there are no traces of Early Harappan cultural material in the interface between the natural soil and Harappan deposits or burials. The level of the natural soil in the

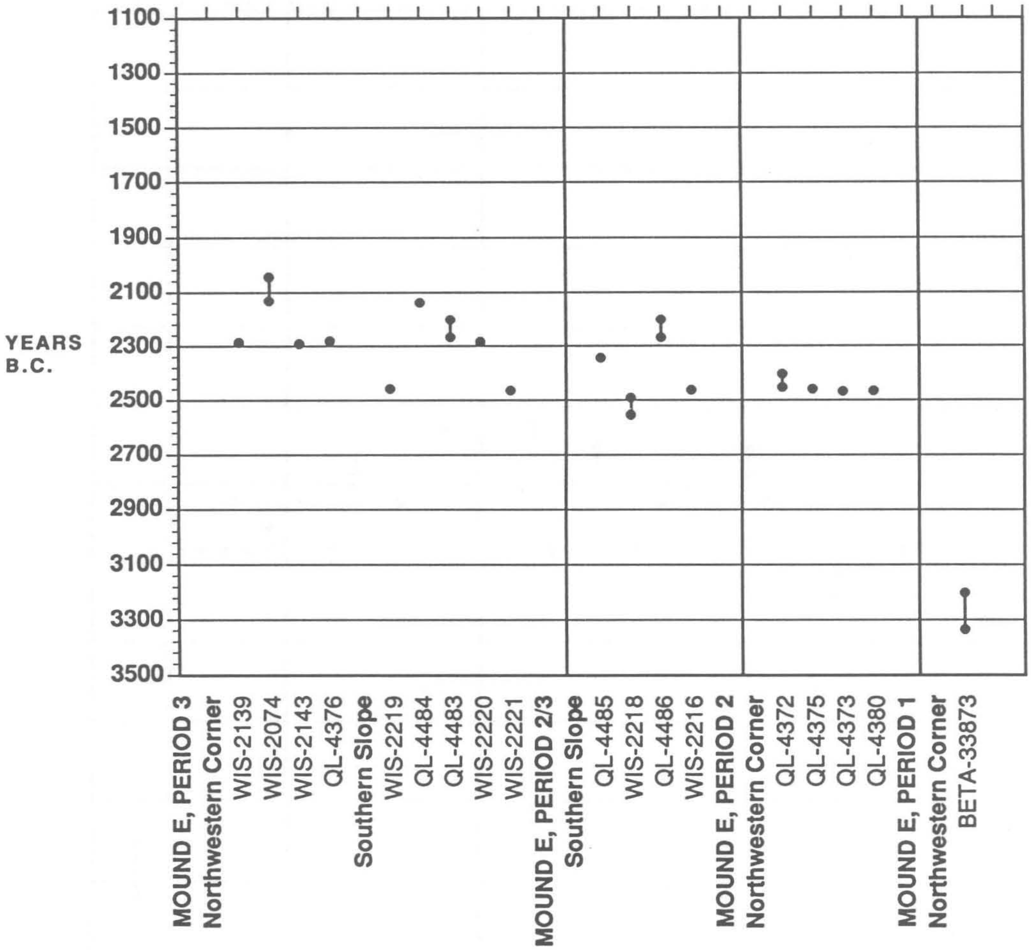

Figure 4.8b: Calibrated Harappa radiocarbon determinations on charcoal from inside hearths and kilns arranged stratigraphically.

cemetery area ranges from 162.80 to 162.60, which is the same as in the highest areas beneath Mound E, some 300 m to the north (Table 4.4).

Evidence for Possible Neolithic Settlement

A single shred of evidence, in the form of a single tiny disc bead made from *Spondylus* shell, exists to suggest that there may be an early, possibly neolithic, settlement buried somewhere under the extensive mounds at Harappa. This type of bead is well documented in the aceramic and ceramic Neolithic at Mehrgarh (6500-4500 BC) (Jarrige and Meadow 1980; Kenoyer 1986) but is not found in later periods at Mehrgarh or at any other known site. The bead was recovered through flotation of sediment from the lower levels of a Period 3 (Harappan phase) street at the southern edge of Mound E.

There are several possible explanations for presence of this bead. It could have been carried to the site by a traveler who found it eroding from a burial in the mountains. It may, however, have been recovered by some Harappan contractor who dug into a Neolithic burial or habitation area to obtain fill for construction or for patching potholes in the street. In any case, this minute bead provides a stimulus to keep looking for an earlier settlement at Harappa.

Period 1

Period 1 refers to the earliest occupation of the site by people of the Early Harappan, or Kot Dijian phase (Mughal 1970, 1990), and corresponds to the Regionalization Era as defined by Shaffer (Kenoyer 1991b; Shaffer 1991).

The cultural affiliation of the Period 1 occupation is based on preliminary observations of ceramics that

Table 4.3: Harappa Dates Arranged Stratigraphically from latest to earliest*

PROVENIENCE	5568 BP	5730 BC	CALIB BC
MOUND AB, Period 3			
WIS-2043	3770 +/- 70	1930+/-70	2268, 2263, 2203, 2147, 2146
WIS-2144	3720 +/- 100	1880+/-105	2138
WIS-2075	3830 +/- 60	1995+/-60	2299
WIS-2140	4290 +/- 70	2470 +/- 70	2913
MOUND E, Period 3			
Northwestern Corner			
WIS-2139**	3820 +/- 60	1985+/-60	2288
WIS-2053	3920 +/- 210	2090+/-215	2469
WIS-2074 **	3700 +/- 60	1861+/-60	2133, 2067, 2047
WIS-2143 **	3825 +/- 60	1990+/-60	2293
WIS-2145	4020 +/- 60	2190 +/- 60	2573, 2535, 2506
WIS-2142	4135 +/- 65	2410 +/- 65	2863, 2812, 2742, 2726, 2696, 2677, 2666
WIS-2141	3920 +/- 70	2090 +/-70	2462
QL-4378	3850 +/- 50	2015+/-50	2334
QL-4374	3800 +/- 50	1965+/-50	2278, 2234, 2209
BETA-33874	4540 +/- 180	2725+/-185	3338, 3213, 3203
QL-4376*	3810 +/- 50	1975+/-50	2283
Southern Slope			
WIS-2217	3860 +/- 60	2026 +/- 60	2343
WIS-2219**	3910 +/- 65	2077 +/- 65	2459
QL-4484**	3730 +/- 30	1892 +/- 30	2140
QL-4483**	3784 +/- 30	1947 +/- 30	2270, 2203
WIS-2220**	3815 +/- 60	1979 +/- 60	2286
WIS-2221**	3940 +/- 120	2108 +/- 120	2466
QL-4488	3750 +/- 40	1912 +/- 40	2191, 2161, 2145
QL-4487	3816 +/- 25	1980 +/- 25	2286
MOUND E, PERIOD 2/3			
Northwestern Corner			
QL-4377	3770 +/- 100	1935+/-105	2198, 2151, 2149
Southern Slope			
QL-4485**	3863 +/- 45	2029+/-45	2346
WIS-2218**	3985 +/- 65	2154 +/- 65	2556, 2546, 2493
QL-4486**	3785 +/- 45	1948 +/- 45	2271, 2260, 2204
WIS-2216**	3930 +/- 65	2098 +/- 65	2464
MOUND E, PERIOD 2			
Northwestern Corner			
QL-4372**	3890 +/- 40	2055+/-40	2455, 2416, 2405
QL-4375**	3920 +/- 40	2090+/-40	2462
QL-4373**	3960 +/- 30	2130+/-30	2470
QL-4380 **	3950 +/- 80	2120+/-80	2468
MOUND E, PERIOD 1			
Northwestern Corner			
BETA-33873**	4540 +/- 85	2725+/-90	3338, 3213, 3203

* The dates are arranged according to the specific stratigraphy in each area of the site. Mound AB dates can only be correlated with Mound E dates on the basis of general ceramic comparisons, but they are approximately equal to the Period 3 dates from Mound E.

** These dates are from charcoal from inside hearths or kilns.

(Acknowledgement: Radiocarbon dates from the Radiocarbon Lab of the Center for Climatic Research, University of Wisconsin-Madison, were supported by the Climate Dynamics Program, National Science Foundation under grant #ATM86-03295.)

Table 4.4. Elevations of "natural soil" found in excavation areas.

Trench Coordinates	Elevation AMSL
Slope to the west	
N1313, E2083	162.80
N1325, E2085.	162.60
N1320, E2079.50	162.08
N1320, E2078.50	161.96
N1346, E2072	161.30
N 1310, E2055	161.07
N1250, E1860	160.00
N1182, E1732	159.80
Slope to the East	
N1313, E2083	162.80
N1020, E2360	162.15
N1015, E2355	162.07
N 985, E2360	162.45
Slope to South	
N1313, E2083	162.80
N1013, E1990	160.80
N 995, E1995	162.60
N 980, E1980.50	160.50 (just above natural soil)

appear identical to examples reported from the Early Harappan levels at Kot Diji (Khan 1965; Mughal 1970), Jalilpur II (Mughal 1974), and Rehman Dheri II (Durrani 1988). In addition to ceramics, there are grey fired bangles, stone blades made from a dark greyish-black chert, a stone celt, various types of stone beads, and human figurines of a type that is not found in the following Harappan period (Period 3).

Primary occupation levels of the Early Harappan period have been found all along the northwestern edge of Mound E and include hearths, accumulations of domestic debris, and traces of mud-brick walls. None of the mud-brick walls from Period 1 have been exposed horizontally, but in section they appear to be oriented in the same direction as walls from the subsequent structures in Period 2 (Figure 4.9).

Period 1 occupations produced an accumulation of considerable domestic debris that resulted in a low mound (Figure 4.10). The northwestern edge of this mound was eventually defined by the construction of a massive mud-brick wall or revetment. The construction of this structure represents an important change in settlement organization, and the subsequent phase of the Early Harappan occupation has been designated Period 2.

Based on the gradual slope that extends from Mound E to the west, it is likely that most of the deposits with Early Harappan sherds discovered beneath Mound AB derive from Period 1 and the subsequent Period 2 occupations on Mound E. These eroded layers appear to have been confined to the portion of the site between Area J and Area F, since Vats does not report any unique sherds from the deep trenches that he excavated in those areas (Figure 4.7).

The total extent of Period 1 deposits is not well defined, but it does not extend as far as the middle of Mound E, nor does it extend out to the west between Mound E and Mound AB (Figure 4.7). On the basis of this limited evidence it appears that the primary settlement was limited to the northwestern corner of Mound E possibly with other hamlets scattered over the plain.

The location and growth of the Period 1 settlement at Harappa can be attributed to the presence of high land in the midst of a rich alluvial plain. The location of the site probably corresponded to major trade and exchange networks that connected the plains to the highlands in the West and North. Continued research on the fauna, flora, and artifacts of Period 1 and comparative regional studies will provide the foundation for more specific interpretations in the future.

Period 2

Stratified deposits of Period 2 have been found along the northwestern corner of Mound E and as far as the middle of Mound E, where they lie directly on the natural soil (Figures 4.6 and 4.7). Of particular note is the construction of massive mud-brick revetments or retaining walls that have been identified at the northwestern periphery of Mound E (Figure 4.9).

These perimeter walls, as well as other structures toward the inside of the mound, were made from

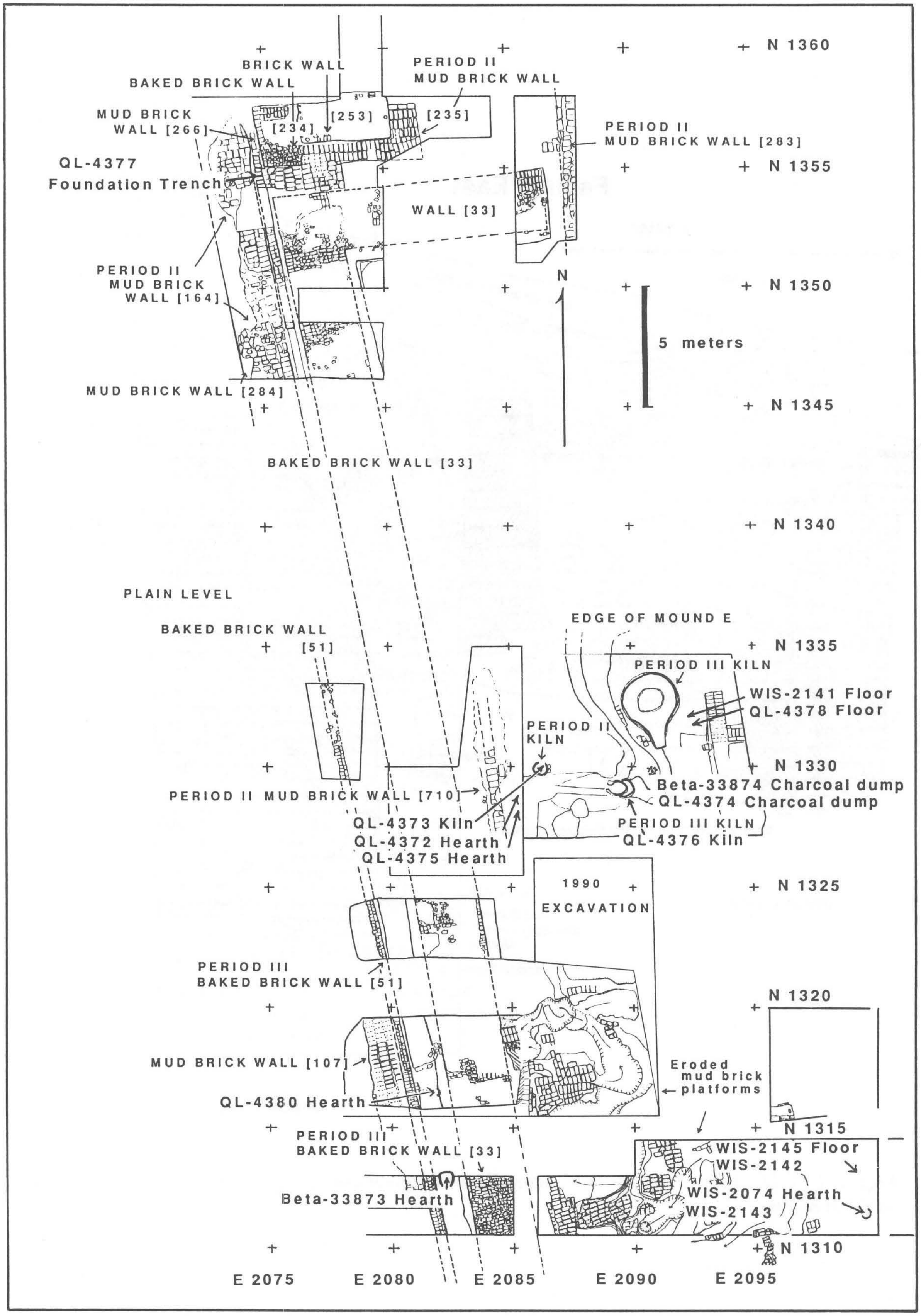

Figure 4.9: Harappa 1990: Plan of northwestern corner of Mound E showing areas excavated and locations from which samples for radiocarbon determination were obtained.

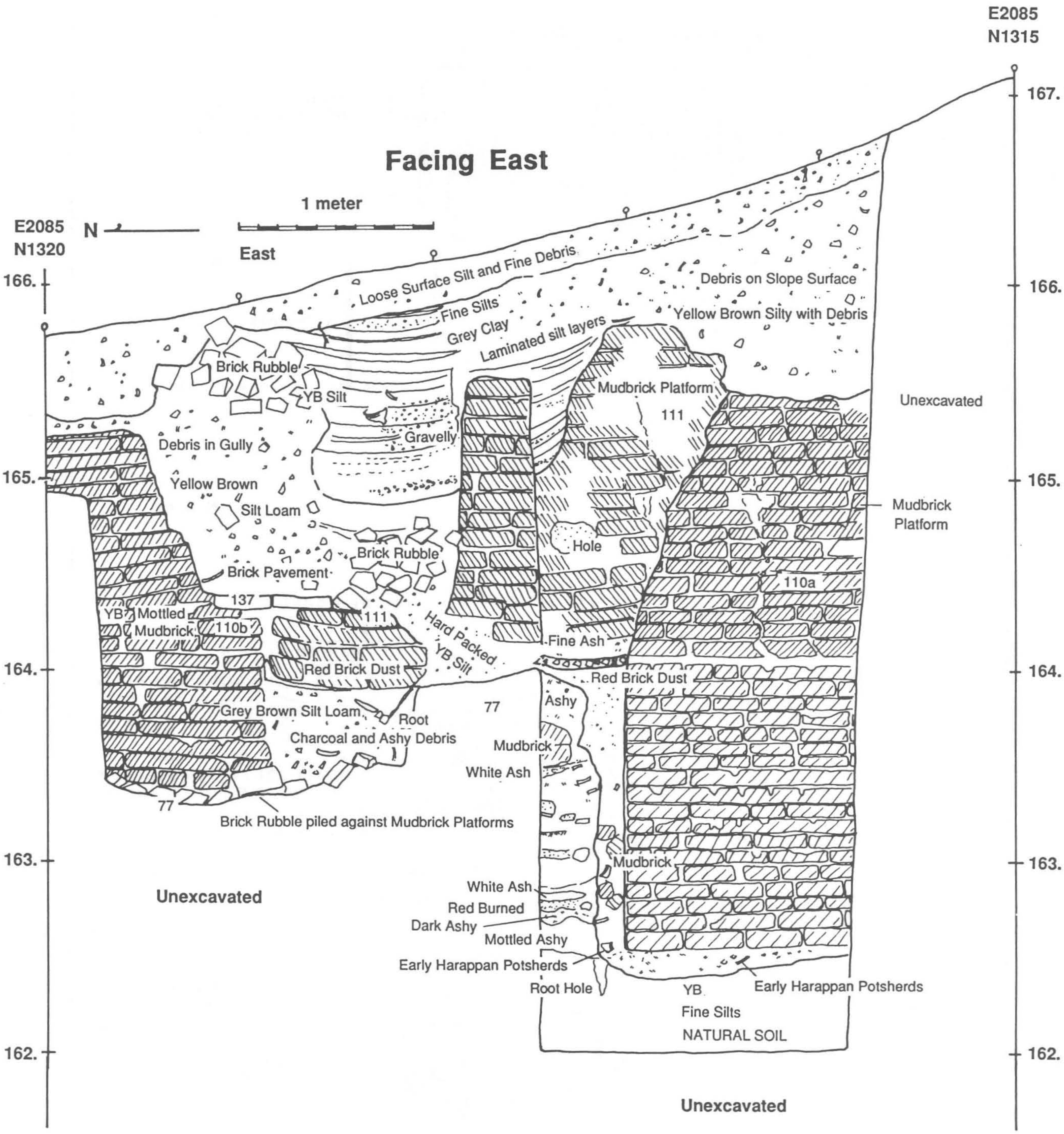

Figure 4.10: Harappa 1988: Section facing East of trench cut through part of the northwestern slope of Mound E.

bricks measuring 10 × 20 × 40 cm (1:2:4 ratio). The orientation of the longer walls is northwest to southeast at an angle of approximately 10° west of true north. Five and possibly six different building phases have been identified, and all are associated with strata containing ceramics similar to those of Period 1 (i.e., Kot Dijian or Early Harappan). Two of the walls are quite heavily eroded and are sealed by later Period 2 deposits, while the other three or four were built on the natural soil or by cutting foundation trenches into Period 1 deposits.

The most complete wall (Feature #[164]) extends north-south for over 15 m (Figure 4.9). It is two meters wide and is preserved to approximately two meters in height. A possible corner of this wall has been identified, but the eastern extension has been completely obliterated by later construction.

Wall #[235] was built after wall #[164]. It is 2.5 m wide and has a well-defined corner and eastern extension that continues for about four meters. The north-south portion of this wall has been obliterated by later Harappan construction, and the exterior face of the corner has been repaired in Period 3 with a baked brick facing.

Both walls #[164] and #[235] were made from mudbricks of distinctly different colors. There does not seem to be any pattern to the use of these bricks, except that often three or four bricks of one color are laid together. This association probably reflects the manner in which bricks were brought from stockpiles to the workmen constructing the wall. The different colors probably represent different source areas for the clay and indicate that the bricks were being prepared in different areas around Harappa and brought to the site for construction of these massive walls.

The precise function of the walls is not clear, but since the exterior face is invariably eroded and the interior face is not eroded, it appears that they may have functioned as retaining or revetment walls or foundations. They could have served to protect the edge of the mound from floods or erosion as well as presenting a formidable elevation to discourage unwanted intruders.

These walls are quite massive, and it is unlikely that this scale of construction would have been undertaken on an individual basis; rather it may reflect some form of Early Harappan social organization capable of mobilizing and controlling the production of large quantities of bricks as well as the labor involved in wall construction.

One particularly significant discovery in the Period 2 levels is a small circular kiln with a unique firing structure made by placing the upper half of a large pot in the center of a circular mud-brick structure. Objects being fired may have been placed inside the pot for high temperature reduction that would have resulted in a dark grey or black color. This structure may have been used for firing the thin greyish black bangles that are common in all of the Early Harappan levels, although no bangles were found inside the kiln itself. This technology in the early phases at Harappa may represent the foundation for the highly advanced technique of stoneware bangle production that has been documented in Period 3 (Blackman and Vidale 1992; Halim and Vidale 1984; Dales, Chapter 5 in this volume).

The layers below, around, and above the Early Harappan kiln contain many vitrified sherds and kiln wasters that indicate the presence of long term ceramic production in this limited area of the settlement. Such production continued into subsequent levels that are associated with Period 3 (see below).

In the later levels of Period 2 there are some stylistic and morphological changes in the ceramics. These reflect a continuity and gradual development or a synthesis of different cultural elements leading up to the ceramic styles of Period 3. Specific ceramic types, figurines, triangular terracotta cakes, terracotta toys, and red fired bangles all continue into Period 3.

An important feature of the later levels of Period 2 is the appearance of tan-brown chert from the Rohri Hills (near the site of Kot Diji) and shell bangles made from the marine shell, *Turbinella pyrum*. These artifacts indicate an expanded network of trade and exchange that extended to the south as far as Rohri and possibly even the coast. The discovery of graffiti on sherds is also an important feature that indicates the increased use of permanent abstract graphic symbols for communication.

Turning to the southern edge of Mound E, there is evidence in this area as well for Period 2 occupation in the form of house walls oriented in the cardinal directions and located along a major north-south street (Figure 4.11). The street is defined by what appear to be cart tracks cutting into natural soil (Figure 4.12) and embedded with late Period 2 type sherds (M.R. Mughal and Farid Khan, personal communications).

These indicators would suggest that the settlement was expanding in the later phases of Period 2 (Figures 4.6 and 4.7) and that habitation areas were constructed along a grid of streets aligned north-south and presumably also east-west. Two phases of mud-brick construction were identified in this area with brick sizes being approximately 6 × 16 × 28 cms (1:2.7:4.7 ratio). Above these structures, ca. 1.5 m of laminated ash and silt deposits contained Early Harappan pottery (late Period 2). Several superimposed hearths contained datable carbon and important concentrations of charred grain. This pattern of superimposed hearths suggests that domestic structures were located

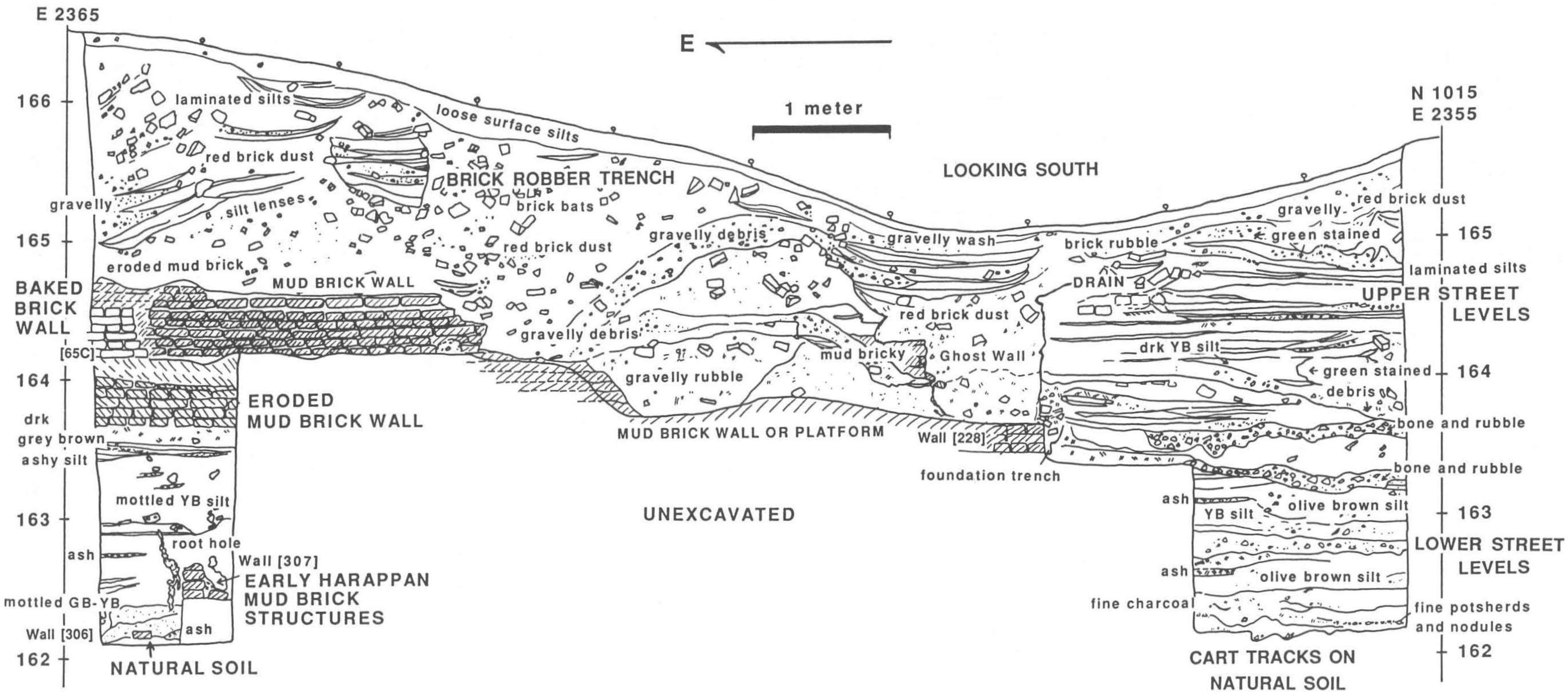

Figure 4.11: Harappa 1990: Section facing South of trench in Area C on the southern side of Mound E.

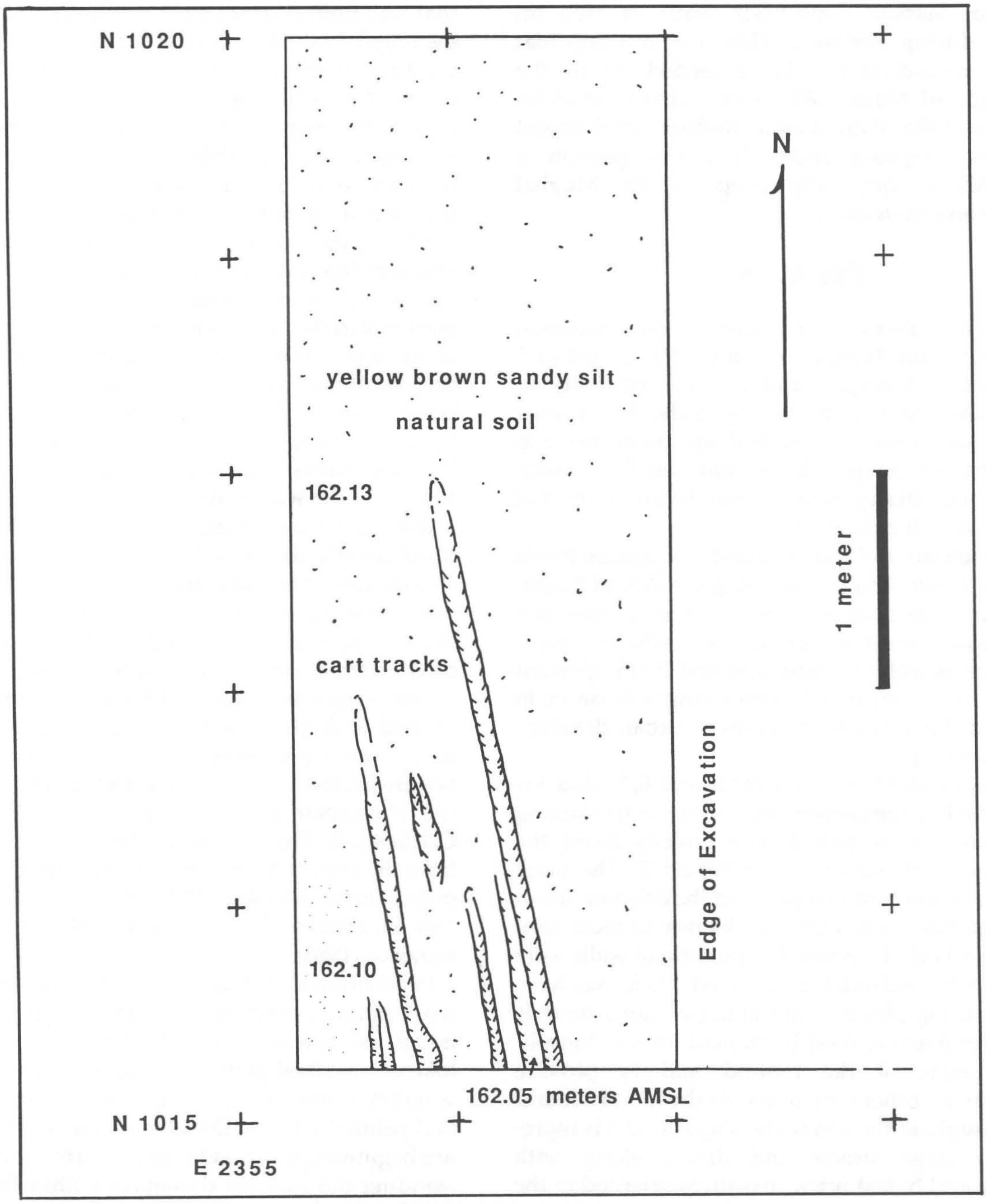

Figure 4.12: Harappa 1990: Plan showing cart tracks in natural sediment in Area C on the southern side of Mound E.

adjacent to the north-south street and that this habitation pattern continued on into the full urban phase of Period 3. Preliminary investigation of the ceramics and the associated artifacts confirms that there was no major hiatus or cultural break between the Early Harappan and Harappan levels in this area, just as there was none in the northwestern part of Mound E.

In view of the structural sequence on Mound E, it is possible that the earliest portions of mud-brick wall seen in Wheeler's section (Figure 4.5) cut into Layer 26A rather than predating it as suggested by Mughal. On the other hand, this structure and Layer 26A are characterized by the presence of Early Harappan pottery and therefore may be correlated to the initial

building of massive mud-brick walls as seen on Mound E during Period 2. This may indicate that massive construction was being carried out on the western side of Mound AB at the same time as on Mound E and that there may be undiscovered Period 2 occupation deposits under the central portion of Mound AB as originally proposed by Mughal (personal communication).

Period 3

Occupations relating to Period 3, the Harappan phase of the Indus Tradition (Shaffer 1991), are found in all areas of Harappa and include the Early to Intermediate strata identified by Vats. The lowest levels of Vats's Late strata would also be included in Period 3, but it is not possible to make precise correlations because stratigraphic subdivisions were not published or well characterized.

It is only on Mound E that Period 3 *occupation* levels have been found directly overlying the Period 2 *occupation*, and there does not appear to have been any hiatus between the two periods. Nevertheless, there was change as well as continuity, and it is important to recognize the nature of these changes in order to understand the various processes of urban development at Harappa.

On the northwestern corner of Mound E, Period 3 is distinguished by the construction of massive retaining walls (Figure 4.9) of baked brick directly above the earlier mud-brick structures of Period 2. The brick bonding techniques of Period 3 and the orientations of the major north-south walls are identical to those seen in the earlier Period 2 walls. The peripheral walls were made of both mud-brick and baked brick and have several building phases. On the upper slope there is evidence for massive mud-brick platforms to consolidate the edge of the mound and to provide foundations for other structures. At the top of Mound E, and throughout the rest of the site, Period 3 is represented by large streets and drains along with mud-brick and baked brick structures oriented to the cardinal directions.

Some scholars have suggested that Harappan urban centers may have been planned as massive platforms on top of which the city and an extensive system of wells and segregated neighborhoods were laid out (Jansen 1987, 1989). However, the evidence from Harappa can be correlated to recent geoarchaeological research at Mohenjo-daro (Balista 1988; Vidale and Balista 1988) to demonstrate that both of these major cities grew in several stages of platform building and reinforcement.

Along the southern edge of Mound E there is evidence for a massive free-standing mud-brick wall that was built directly on the natural plain surface at the edge of the settlement (Figures 4.13 and 4.14). The mud-bricks measure 10 × 20 × 40 cm, and Period 3 ceramics have been found beneath the wall and mixed in with the mortar. The pattern of brick bonding and the distribution of different colored mud-bricks is identical to that seen in the earlier Period 2 walls. This indicates a continuity in architectural technology and similar patterns of raw material acquisition from surrounding clay sources.

This wall was pierced with a gateway that was approximately 2.8 m wide and appears to have been faced with baked brick (Figure 4.15). The street running through the gateway was paved with crushed pottery and fired terracotta nodules and connected to a major street running east-west inside the wall. Possible street levels also were found along the outside of the wall as well.

Inside the wall, a major north-south street was identified directly above the Period 2 street. This street was five meters wide and could have accommodated two-way traffic of ox carts. Mud-brick and baked brick houses equipped with baked brick drains were constructed along the edges of the street (Figure 4.16).

The revetment walls in the northwestern corner of Mound E, the free standing wall and gateway on the south, and the various habitation and kiln structures are associated with ceramics that are characteristic of the Harappan or full urban phase of the Indus Civilization. These ceramics have been documented from the sites of Mohenjo-daro and Harappa in earlier publications (Marshall 1931; Mackay 1938; Vats 1940) and in greater detail most recently by Dales and Kenoyer (1986).

In addition to baked brick architecture and distinctive ceramics, other new varieties of artifacts include intaglio steatite seals, inscribed steatite tokens, faience tokens, inscribed pottery, tan-brown chert tools, stone weights, terracotta cones, distinctive figurines, toys, and painted pottery. Detailed studies of these artifacts are beginning to provide new information for understanding the cultural dynamics within Period 3 and will help to further define the sub-periods discussed next.

In both Mound E and Mound AB, various categories of evidence from the recent excavations point to the existence of at least three sub-periods of the Period 3 urban settlement. These sub-periods do not relate simply to architectural building phases, but to larger episodes of urban growth and decay.

In the initial levels of Period 3 (Period 3A) along the southern edge of Mound E, distinctive artifacts include terracotta bull figurines with legs joined together, a chert weight, a copper arrow point, tan-brown chert tools, and a single fragment of an intaglio

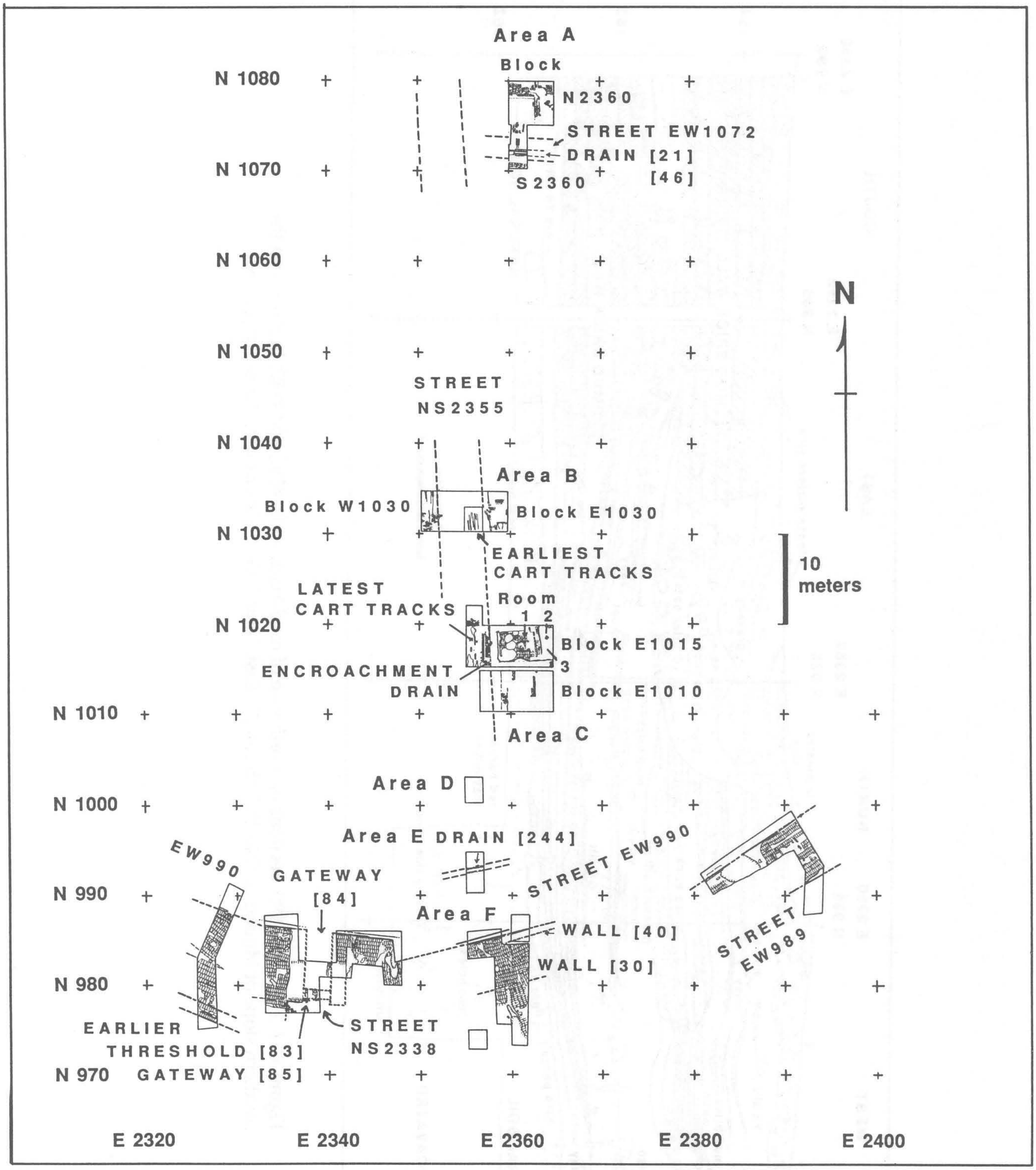

Figure 4.13: Harappa 1990: Plan of excavated areas on southern slope of Mound E.

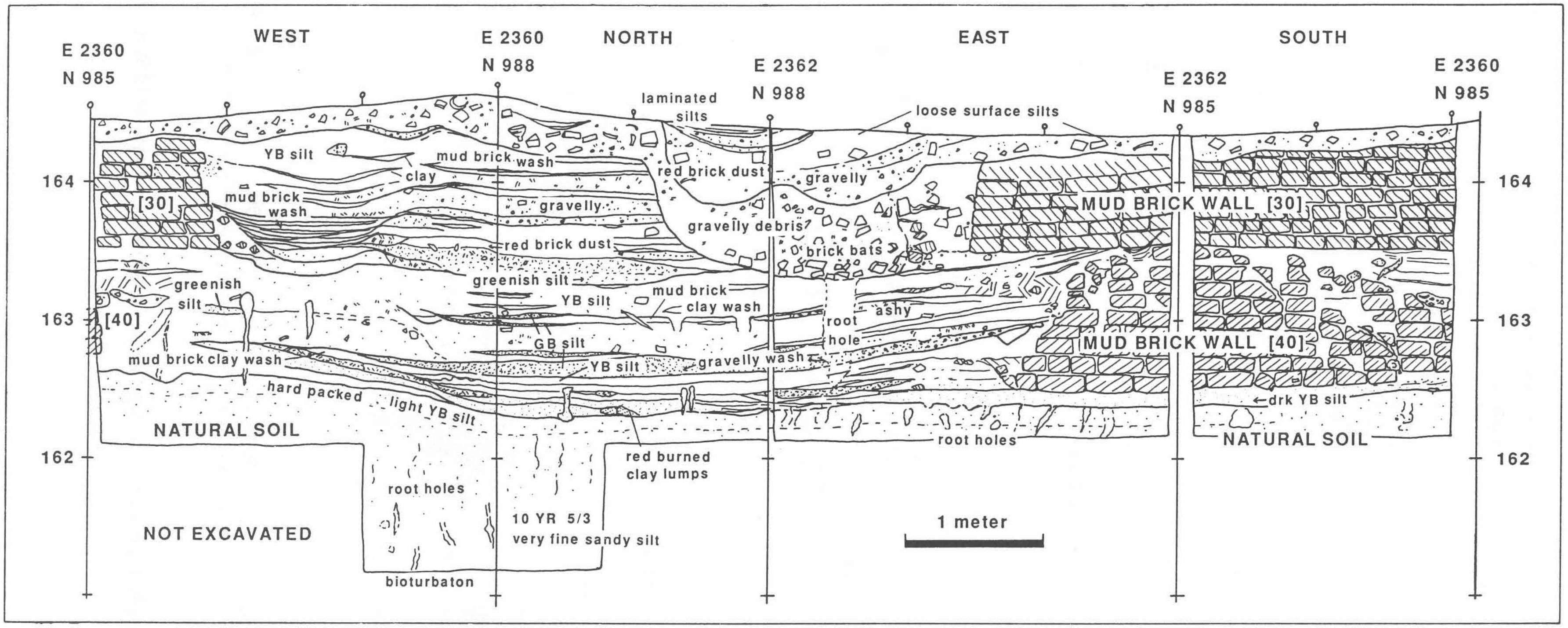

Figure 4.14: Harappa 1990: Sections on north side of mud-brick walls #[30] and #[40] in Area F on the southern slope of Mound E. "North," "South," "East," and "West" denote directions being faced.

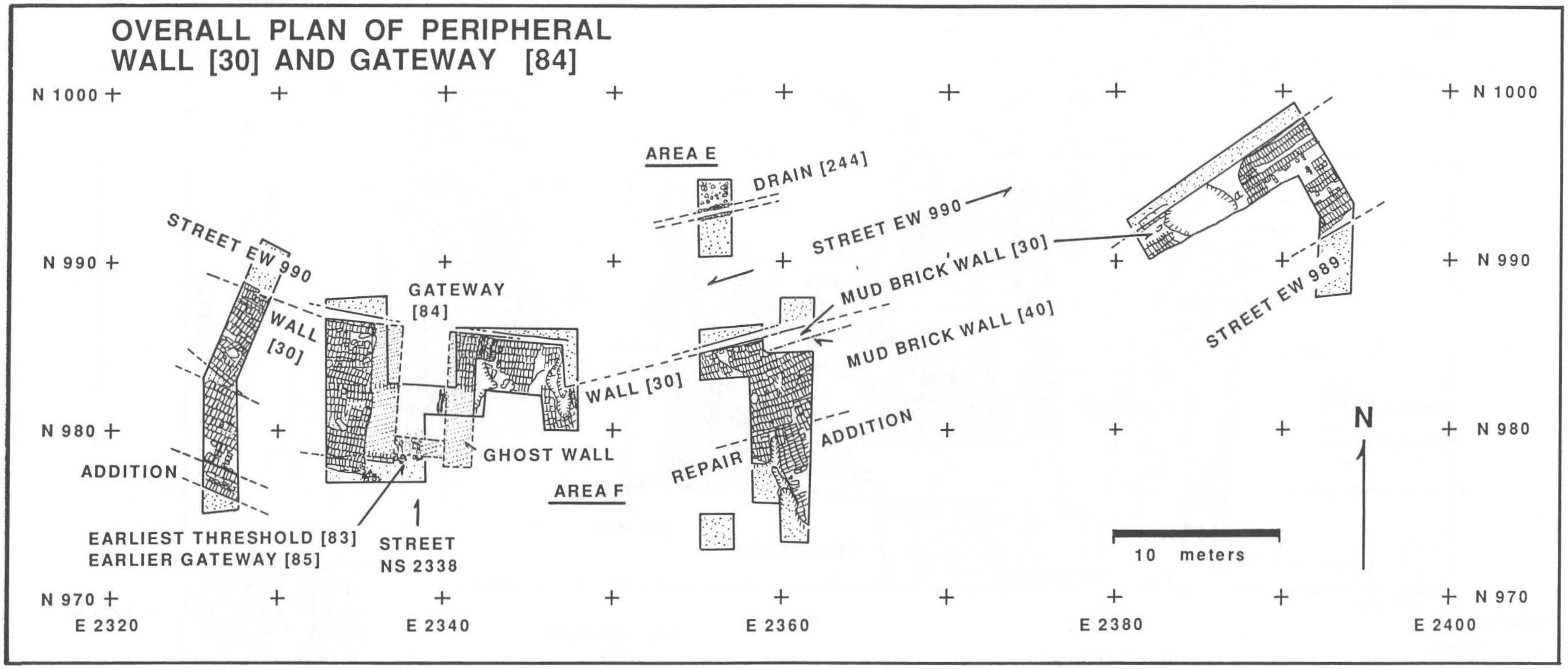

Figure 4.15: Harappa 1990: Overall plan of peripheral wall #[30] and gateway #[84] on southern slope of Mound E.

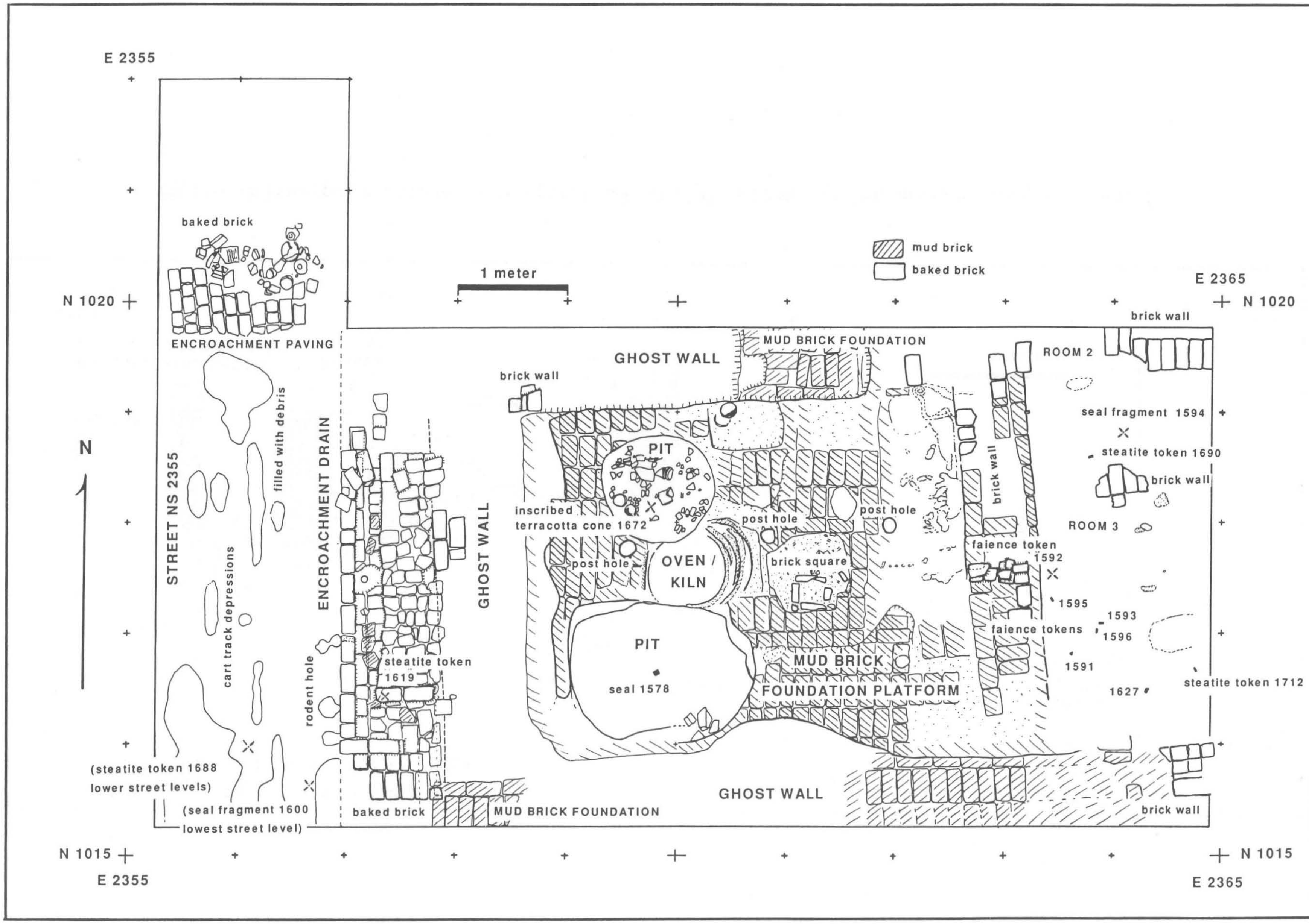

Figure 4.16: Harappa 1990: Plan of house structure and upper street levels in Area C on the southern slope of Mound E.

steatite seal. No examples of tiny inscribed steatite tokens or faience sealings have been recovered to date. The ceramics in these earlier levels incorporate some stylistic continuities from Period 2, but the most noteworthy types are the elaborately painted ceramics (black paint on red slip) characteristic of Period 3. These distinctive ceramics are also found in the earliest burials of the Harappan cemetery, but do not continue in the later burials (Dales and Kenoyer 1989a) (Figure 4.17).

The initial Period 3A habitation deposits on the southern edge of Mound E are followed by a period of civic decay and disrepair. The street drains became clogged and sewage flowed in the street, the wall and gateway became eroded and non-functional, and carcasses of animals were left lying in the street or dumped into abandoned rooms along the street (Dales and Kenoyer 1990; Chapter 13 in this volume; and Meadow, Chapter 7 in this volume).

The following Period 3B is marked by a dramatic clean-up operation on the south side of Mound E, with new drains, a new southern wall and gateway, and new house structures. The rebuilt wall has been traced for over 73 m along the edge of the mound and ranges from 5.4 to as many as 11 m wide. The wider portions appear to be repairs and additions, although they could also represent towers. At the gateway the wall was 8.5 m wide, and the gateway itself was faced with baked brick, 1.6 m thick. The wall was free-standing, and on the basis of one meter deep foundations, it probably stood several meters above the plain.

Most of the material culture characteristic of Period 3A such as intaglio steatite seals, chert weights, tan-brown chert, and painted ceramics continued to be used, but there is now evidence for the use of tiny steatite and faience tokens. Other varieties of objects with writing include inscribed or stamped pottery, inscribed stoneware bangles, inscribed terracotta cones, and impressed terracotta sealings that appear to have been broken from sealed vessels, bales, or doors. These various objects with writing have been found in primary and secondary contexts within the habitation areas and in the street leading towards the gateway.

During this sub-period, however, the joined leg terra-cotta bull figurines were no longer in use. Furthermore, the new forms of animal figurines with separated legs were made in many different styles and can be related to those found at Mohenjo-daro and other sites in the greater Indus Valley. In contrast to the earlier Period 3A, much of the pottery is unpainted

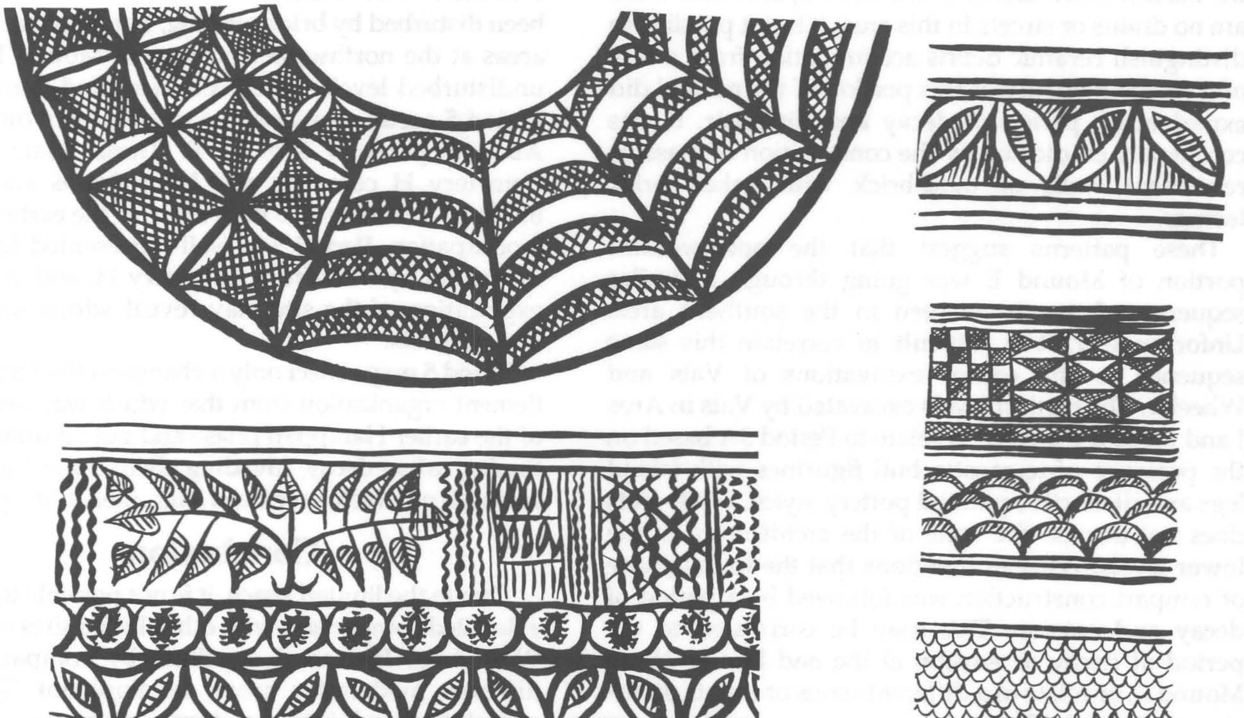

Figure 4.17: Harappa 1988: Painted pottery motifs from vessels found in the Harappan phase cemetery (Period 3).

and unslipped and can be correlated to the later burials in the Harappan cemetery.

In the final levels of Period 3 (Period 3C), pointed-base goblets, a form of disposable drinking vessel, became quite common. These are particularly numerous in the levels that cover the Harappan phase cemetery, but also occur in the upper levels on the south side of Mound E where brick pavings and drains were built in what used to be the five-meter-wide street, effectively encroaching on the thoroughfare and contributing to congestion. Unfortunately, most of the levels of this sub-period on the south side of Mound E have been disturbed by brick robbing.

In the northwestern corner of Mound E, terracotta bull figurines with joined legs are found in the initial levels of Period 3 but do not continue in the later levels. Inscribed steatite tokens and faience tokens have not been found in the lower levels nor in the later stratified deposits associated with the ceramic production area. However, they have been found in disturbed layers left by brick robbing and derive from habitation levels that are distinct from the ceramic production area.

Two kilns in the Period 3 levels above the Period 2 kiln attest to the continuity of ceramic production in the northwestern corner of the mound, and since there are no drains or streets in this area, it is not possible to distinguish ceramic debris accumulation from a lack of civic maintenance. If this portion of the mound did experience a period of decay and disrepair, it was completely eradicated by the construction of massive revetment walls of mud-brick with baked brick facings.

These patterns suggest that the northwestern portion of Mound E was going through a similar sequence of events as seen in the southern area. Unfortunately, it is difficult to correlate this same sequence to the earlier excavations of Vats and Wheeler. The earliest levels excavated by Vats in Area J and Mound F appear to relate to Period 3A based on the presence of terracotta bull figurines with joined legs and distinctive painted pottery styles. While Vats does not discuss the state of the architecture in the lower levels, Wheeler mentions that the initial phase of rampart construction was followed by a period of decay and erosion. This may be correlated to the period of decay or erosion at the end Period 3B on Mound E, or relate to a different series of events occurring on Mound AB.

Vats notes that the lower levels of Mound F and Area J have numerous examples of tiny inscribed steatite tokens and faience tokens. These levels probably correspond to the upper levels of Period 3B on Mound E. The upper levels of Mound F and the massive deposits of Mound AB may represent Period 3C which is less massive on Mound E. Wheeler's designation of two additional periods of rampart repair and construction could relate to Period 3B and possibly 3C.

Period 4

The Period 4 designation is applied to stratified deposits on Mound E and possibly on Mound AB that have ceramics which are not readily identified as either Mature Harappan or Late Harappan/Cemetery H. These ceramics appear to represent a transitional period prior to the development of Cemetery H culture. There is no distinct architectural division that differentiates levels of the Period 3 from Period 4, and definition of this period is based on preliminary observations of the ceramics and other artifact categories. On the basis of ceramic styles and morphology, some of the latest burials in the recent cemetery excavations as well as some of the early burials in the Cemetery H excavations by Vats (1940) may be associated with Period 4.

Period 5

The final occupation of the protohistoric period is characterized by Cemetery H or Late Harappan ceramics. Most of the strata with these ceramics have been disturbed by brick robbing, but there are isolated areas at the northwestern corner of Mound E where undisturbed levels have been identified. Most of the Period 5 occupation appears to have been on Mound AB and parts of Mound F. These strata contain Cemetery H ceramics and have drains and baked bricks of a smaller size than those of the earlier Period 3 occupation. Period 5 is well-represented in burials excavated by Vats from Cemetery H, and continued exploration of the site may reveal additional undisturbed levels.

Period 5 may reflect only a change in the focus of settlement organization from that which was the pattern of the earlier Harappan phase and not cultural discontinuity, urban decay, invading aliens, or site abandonment, all of which have been suggested in the past.

Conclusion

Due to the limited space, it is not possible to present a detailed comparison with other Indus sites or sites in West Asia. Instead, I conclude by comparing two different models for urban development. The most straightforward interpretation, commonly used for ancient cities in South and West Asia, uses a model of gradual or punctuated site expansion interrupted by periods of abandonment or contraction and finally collapse (e.g., Marshall 1931; Mackay 1938; Vats 1940; Wheeler 1947).

Based on this model, one could suggest that the initial Period 1 settlement on Mound E gradually expanded to the east during Period 2. Period 3A occupations developed on Mound E and expanded to the east and west covering the rest of the known site. Periods of abandonment due to floods or political disorders would explain the weathering of the ramparts and walls on both mounds. Reoccupation and urban renewal occurred over the entire site simultaneously, followed again by gradual decay, disorder, and abandonment.

A different model can be derived from observations of historical cities and traditional settlements in South Asia. This model correlates the various settlement patterns to fluctuations in control and a shifting focus of urban development by different ruling elites. When new groups come into power they often change the locus of power and build up their own neighborhoods or establish new areas of the city, while the old centers of power become delapidated. City growth and site formation processes are directly affected by such events.

The total area of the settlement during any one period would represent the maximum extent of occupation but cannot be taken to represent population density. During specific seasons, urban centers become the focus of activity for traders, nomads, agriculturalists, and ritual specialists. Some people live with relatives in the city, others camp in the fields or on top of the city dumps. The population dynamics of a city in South Asia, and for that matter of all cities, is not a simple equation to numbers of people who can exist in a given area.

Initial growth from a small to large settlement would have occurred in Periods 1 and 2 through the increased importance of the site for trade and probably also socio-ritual activities. Harappa is located on an important crossroads connecting the western highlands and northern plains to the Ghaggar-Hakra Valley and the southern plains. Evidence of expanded trade networks reaching to the south is evident in Period 2. The increase in settlement size can be explained through agglomeration of peripheral communities, as well as through gradual population growth.

Major sociopolitical integration is represented by the delimitation and protection of the site through the construction of massive mud-brick walls, revetments, and platforms. Large north-south streets and segregated areas for habitation and craft activities were established during Period 2, commonly referred to as the Early Harappan or Kot Dijian phase.

The development of Period 3A on Mound E represents the initial establishment of the dominant elite groups associated with the Harappan phase. Settlement organization followed the basic layout defined in Period 2, with similar activities continuing in the same areas of the site. However, there appears to have been continued expansion over much of Mound E, Mound F, and Area J. It is also quite probable that the Period 3A occupation will be found beneath Mound AB. Modern Harappa town, which covers approximately one quarter of the total area of the site, may cover areas of Period 3A expansion, but no traces are visible on the surface.

Period 3A expansion appears to have coincided with regional alliances and the integration of the Greater Indus Valley through trade and shared socio-ritual beliefs. The massive wall and narrow gateway on the southern edge of Mound E may indicate that there was some degree of conflict present, but armed conflict does not appear to have been a major activity of this culture, nor is there any indication that the integration of the Indus Valley was achieved through extensive military coercion. Any military conquest that would have been effective over such a large area should have left some clear evidence in the archaeological record. We do see evidence for what may be walled settlements, particularly in the piedmont and peripheral zones, but evidence for periods of sustained conflict and a coercive militaristic hegemony is not found.

During Period 3A we see the use of distinctive ceramic styles, figurine styles, intaglio seals, chert weights, and a large number of new ornament styles. These various objects reflect the many different communities and occupations that became established in the city (Kenoyer 1989, 1991a, 1991b, 1992).

After the Period 3A expansion, it is possible that the focus of development temporarily shifted to the west. The lack of civic maintenance and accumulation of garbage on Mound E may reflect a shift in socioeconomic control and political focus to Mound AB, where there was extensive construction and site build-up. This shift may correspond to the development of merchant classes or ruling elites and new socioeconomic or political organization. The use of tiny steatite tokens and faience tokens may have begun at this time.

The subsequent Period 3B renewal of Mound E may correspond to structural decay on Mound AB. Several phases of repair and construction are noted by Wheeler and Vats for Mounds AB and F, but it is not clear how these are correlated to developments on Mound E.

Finally, during Period 3C there is evidence of extensive congestion in many areas of the site and a general lack of civic control. Whereas in the past this pattern has been interpreted as a break down of political control, it also could reflect overpopulation of the mounds due to increased centripetal forces. Period 5 occupations, which appear to have been focused on

Mound AB and extended to parts of Mound E and F, may represent another phase of control that provided order to specific areas of the site.

The first model reflects an extremely simplistic perception of urban dynamics and does not take into account fluctuating political and socioeconomic factors that undoubtedly were functioning in these early cities. The second model is much more complicated, and although it may reflect the dynamics of early urban development, it will require considerable refinement. Our excavations at Harappa have been designed to collect the types of data needed to test these models, and I am confident that through our current analyses and future excavations we will be able to provide a more reliable perspective of urban dynamics during the Harappan phase of the Indus Tradition.

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Cover art: Bowl on Stand H88-1002/192-17 associated with Burial 194a
in Harappan Phase Cemetery (see Figure 13.18).

5

Some Specialized Ceramic Studies at Harappa

George F. Dales
University of California-Berkeley

The craftsmen of the Harappan civilization produced a range of ceramic items that are often technologically and aesthetically outstanding. Among them are pottery vessels, clay figurines, stoneware bangles, and faience artifacts. New data on these categories of ceramic production, which epitomize the advanced state and refinement of pyrotechnological production during the Harappan period, have been collected during five seasons of excavations at the site of Harappa. While involving typologies, chemical characterizations, and chronological sequences, study of these materials at Harappa goes well beyond to include consideration of distribution patterns, contexts, and associations with other categories of artifacts. Thus do we try to obtain a more accurate and sensitive understanding of the technological and artistic achievements of the Harappans and how they influenced, and were influenced by, different aspects of the socio-economic and cultural systems.

Five seasons of excavations at Harappa (1986–1990) have yielded a formidable quantity and variety of new data. These finds are providing an opportunity for the introduction and testing of new descriptive and analytical procedures, for a program of experimental archaeology, and for developing new hypotheses concerning the still enigmatic Indus Civilization.

We are learning new and redefining old ways of describing and interpreting manufactured items from a pre-modern-machine society. Note I do not say "pre-industrial" society. The Harappans are the quintessential example of a society obsessed with production, indeed mass production. That they did not have electricity and Stanley lathes and drill presses is beside the point. In addition to their often prodigious technological competence, they could be excellent artisans and craftsmen. For example, they produced a range of ceramic items that technologically and aesthetically are on a par with, and often surpass, products of other cultures in the ancient South Asian and Near Eastern worlds.

Here I wish to describe four categories of artifacts that are among the most significant products of the ceramic industry at Harappa. Pottery is the largest and most complex category of products. Second, there is a large and important new collection of clay figurines of both animal and anthropoid representations. Third, there are the remarkable stoneware bangles—the world's earliest examples of this sophisticated technology. And fourth, there are the various ornaments and vessels made of faience. I have selected these four categories of ceramic products because they epitomize the advanced state and refinement of pyrotechnological production during the Harappan periods.

The Pottery

To date, we have registered 614 complete or restorable vessels from our excavations at Harappa, and our sherd collection far exceeds one million items.

In my introductory remarks to this volume (Chapter 1), I mentioned the unique significance of Harappa as a site and the superb opportunities it offers for studying the evolution and interactions of a major urban settlement. The pottery is one of the foremost components in these studies. Because of the huge quantities of data available, we must constantly maintain a balance

between becoming stifled by the enormity of the task and taking advantage of the opportunities for using the pottery to address specific intra- and inter-site problems.

Also, we are firm in our conviction that pottery should not be used as the sole or even primary indicator to define "phases" or "periods." Categories of artifacts other than pottery are often more sensitive to social, economic, political, and cultural change. Synergistic analyses of the various assemblages of artifacts, within a carefully documented contextual framework, is leading to significant new interpretations both of the site and of Harappan society.

To use the pottery data in this way, it is essential that we maintain strict control over it. This means, first of all, establishing the reliability of the excavation units; second, understanding the site formation processes that effected the contents of the excavation units; and third, having an accurate and efficient classification system for complete vessels and sherds alike.

The most detailed system available for classifying Indus pottery was devised by myself and J. Mark Kenoyer (1986) for pottery from Mohenjo-daro. The basic approach that was developed is quite practical and efficient, but it has a major shortcoming: it was not built on a solid statistical framework. It is basically an empirical system. We did things differently in South Asia back in 1964 when I excavated the pottery that formed the basis for our Mohenjo-daro system.

When we began the Harappa project, we used the Mohenjo-daro classification system knowing full well that it would need to be modified to accommodate regional, functional, temporal and preferential variants. And so it has. For example, most of the complete or restorable vessels we have excavated to date at Harappa have come from the cemetery, so we have a significant contextual difference from that of the Mohenjo-daro pottery. In addition, the Harappa Museum has in its storeroom an unparalleled collection of complete vessels from the earlier excavations at the site. Although the original field registers are not available, the inked (sometimes painted) letters and numbers on most of the vessels identify the areas of the site where the vessels were excavated. Many of the vessels in the storage collection have provided additional information as to the variations inherent in each of our newly established vessel categories.

To help in operationalizing our pottery studies at Harappa, Paul Chrisy Jenkins has been applying his considerable computer skills to the task of constructing a multi-variant classification system based on the full range of complete vessels and sherds, encompassing morphological, stylistic, and contextual analyses while being tolerant of a degree of empirical, intuitive observation.

These aspects of the pottery studies are complemented by the technological studies of Rita Wright (Chapter 6 in this volume) who is analyzing the raw materials used, the manufacturing techniques, the firing temperatures, and the social implications of these technological patterns in the context of different activity areas within the site.

Because of the sharp focus of our excavations in the cemetery with its well-defined contexts, and because such a high percentage of the pottery vessels from the burials are either complete or restorable, our initial study of the Harappa pottery has concentrated mainly on the vessels from that area of the site. Many of the modifications in the Mohenjo-daro classification system have resulted from the study and analysis of the burial vessels. In addition to refining the typological system, we are studying the range and quantities of vessel types in each burial in relation to factors such as sex and age of the individuals and the presence of other classes of grave goods.

The analyses of the cemetery pottery is far from complete, but there are a few observations that are of particular interest even at this early stage. First, an overwhelming percentage of the pottery is undecorated, not even having surface slips. The examples of slipped and painted vessels that we have excavated—and there are many examples in virtually mint condition (Figure 5.1)—were found in the lower levels of the cemetery. This suggests a significant change in the burial customs through time. But such a hypothesis is subject to several conditions. There is, for example, no way to determine anything more precise than a relative chronology for the burials. The relative richness of each burial in terms of the type of interment (with or without wooden coffin), the kinds of ornaments associated with each body, and the types and quantities of pottery included in each burial are still under study.

There is another possible factor involved in this seeming shift from decorated to plain pottery in graves. We have documented numerous examples of differential preservation of vessels, even within the same burial. There may be chemical explanations for this phenomenon, perhaps having to do with the contents in the vessels when they were buried, or possibly there are factors relating to manufacturing and firing that made some vessels virtually indestructible while others have disintegrated to flakes and dust. We have, in fact, examples of vessels that, immediately upon exposure in the excavations, showed traces of red slip. But the traces were little more than powder on the surface of the vessels and could not be

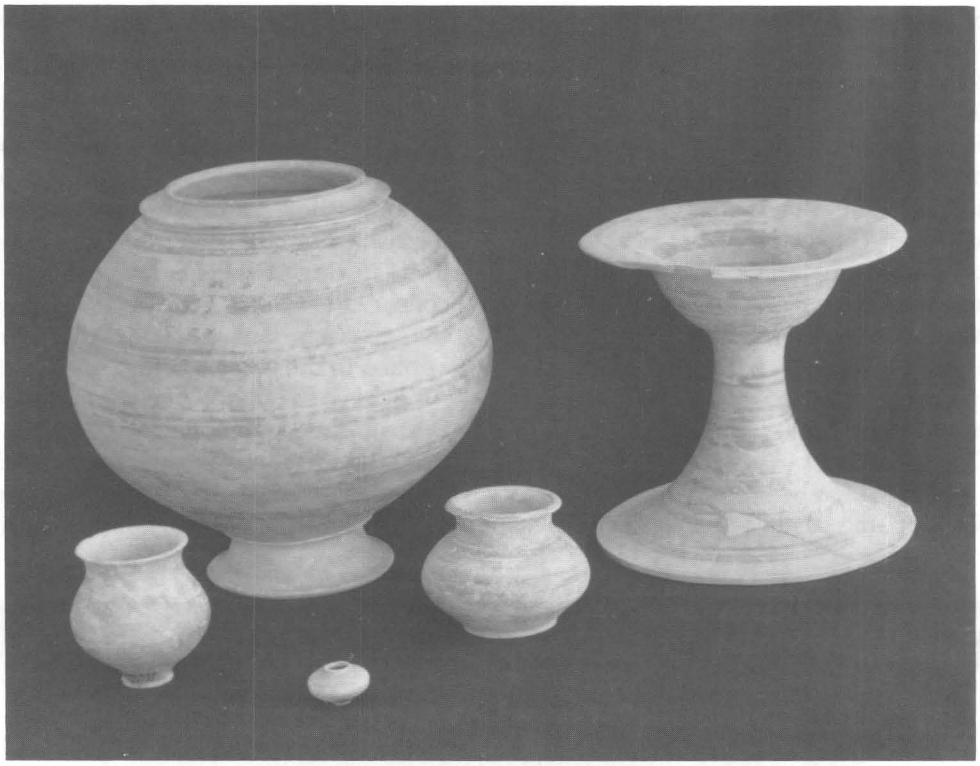

Figure 5.1: Harappan phase cemetery: selection of burial pottery. Large pot on left: maximum body diameter, 29.7 cm; total height, 29.5 cm. Bowl-on-stand on right: diameter of bowl, 23.2 cm; total height, 22.6 cm.

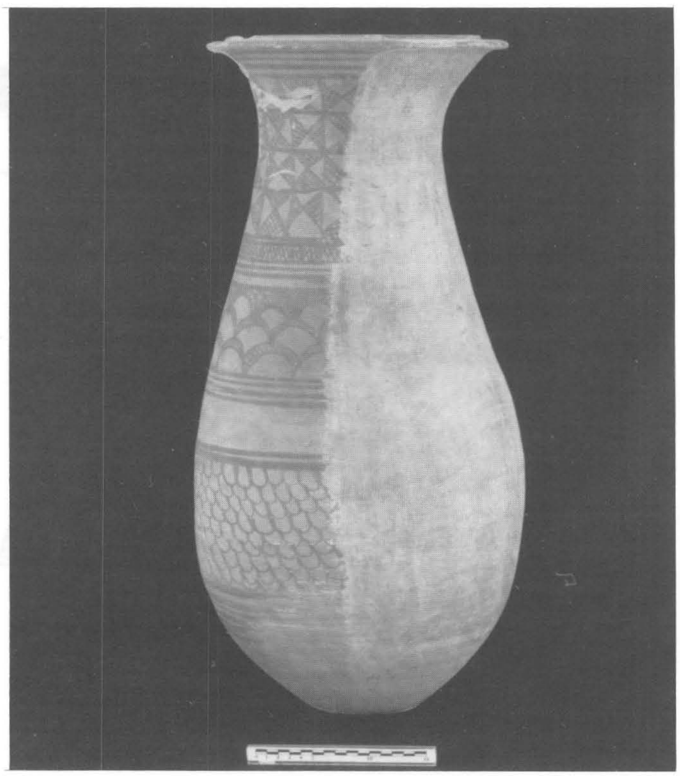

Figure 5.2: Harappan phase cemetery: jar with intentional coating(s) of clay (half removed) that covered decoration; H87-655/145-156.

consolidated or preserved. This suggests that there originally may have been a higher proportion of decorated vessels than our current record indicates.

And there is yet another aspect of the cemetery pottery that is unique, as far as we know from published records of other Harappan period burials. There is a strong indication that the Harappans themselves may have been conscious of the problems of preservation of buried materials. We have found various instances where the Harappans applied coatings to the surfaces of vessels, possibly to protect the surfaces from direct contact with the earth. An example from a grave excavated in the 1987 season is illustrated here as Figure 5.2 (see also Chapter 13 in this volume). This vessel is a tall, sinuous jar that has a solid red slip upon which were painted elaborate designs in black paint that were subsequently obscured by an outer coating or coatings of a clay-like material that is reddish on the exterior and greyish below.

During the 1988 season (Chapter 13 in this volume), groups of jars were uncovered in the cemetery that were encrusted with thick whitish deposits. At first we thought they were simply unusually heavy salt deposits, but based on what was noted in the laboratory during the cleaning of these vessels, our conservator Donna Strahan (1991) has suggested that the coatings are gypsum that was intentionally applied to the vessels before interment.

We have also made important discoveries of pottery in areas outside the cemetery. Notable are the ceramics from the so-called "Early Indus" or "Early Harappan" phase (Figure 5.3), which are like those from such sites as Kot Diji (Khan 1965), Jalilpur (Mughal 1972, 1974),

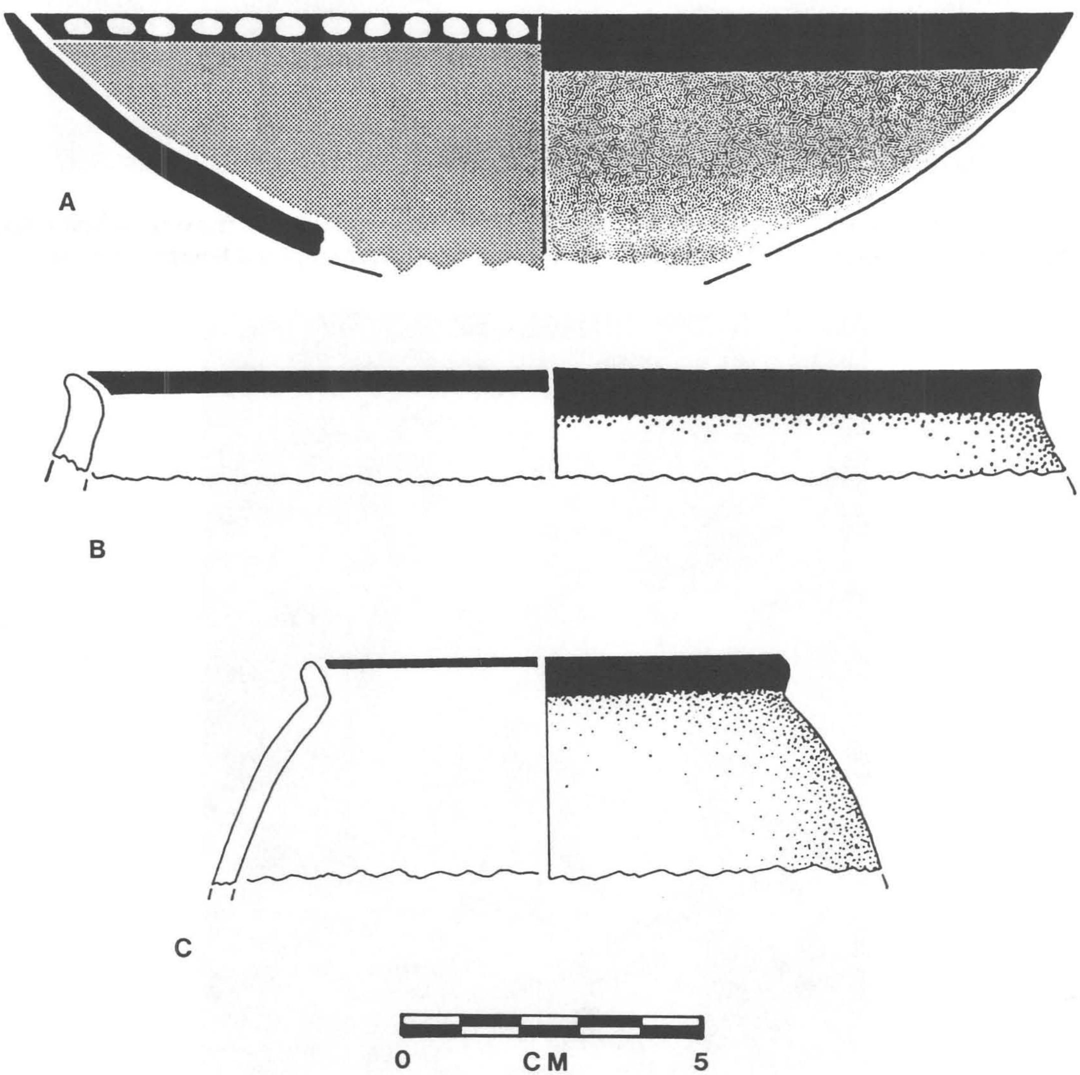

Figure 5.3: Early Harappan (Period 1/2) ceramics from Harappa, Mound E, northwestern corner.

and Rehman Dheri (Durrani 1988). The presence of such remains at Harappa was first noted by Wheeler (1947) in 1946 when he discovered characteristically "Early" sherds beneath the massive walls along the western edge of Mound AB. After several unsuccessful attempts during our first two seasons, we located remains of the early settlement resting on the natural ground surface at the northwestern corner of Mound E, beneath massive remains of our Period 3 Harappan phase (see Chapters 4 and 13 in this volume).

During these excavations on Mound E, between the identified remains of the Early Harappan and Harappan phases (Periods 1 and 3), we find pottery that is stratigraphically and stylistically intermediate (Figure 5.4). Together with this pottery are grey-ware bangles and figurines of humans and animals that again are not "typically" Early Harappan or Harappan. As there is no evidence for catastrophic discontinuity in the occupational deposits— at least in the areas of Mound E that we have investigated—we hypothesize that there was a continuous, smooth transitional phase between these two periods. Such an hypothesis is of crucial importance to discussions of the origins and early development of the urban Indus culture and requires testing in other parts of the site.

Figurines

Clay figurines of animals and human forms are abundant at Harappa. None have been found directly in burials, but they are numerous in the thick layer of Harappan debris that covers parts of the cemetery. No figurines have yet been excavated in contexts that can be identified with ritual or other specialized practices,

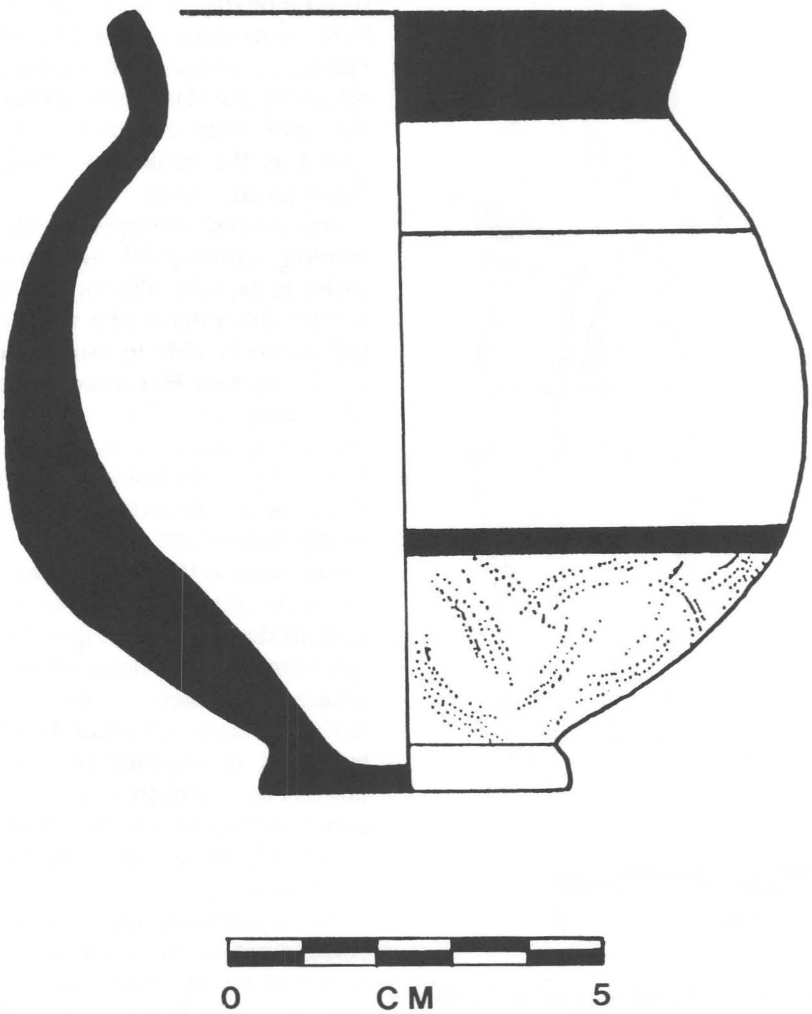

Figure 5.4: Transitional (Period 2) pot from Harappa, Mound E, northwestern corner.

although the figurines themselves, especially the anthropoid examples, display features suggesting that ritual of some sort was inherent in their manufacture.

First, most of the female figurines are in a stiff, erect position which in itself is not unusual for Old World figurines. But the Harappa examples show absolute evidence of having been made in vertical halves, each half including the entire body from head to foot (Figure 5.5). This manufacturing feature was noted first as we were tabulating the many fragment of human legs and bodies. Then, closer examination of complete figurines showed vertical seams from the top of the head to the bottom of the torso of standing females but not of males. The seams are most visible on the backsides of the figurines where they are not obscured by applied clothing and ornamentation. To obtain further verification for this unusual manufacturing practice, we X-rayed several complete examples of both female and male figurines that had no surface indications of seams. The seams show clearly in the X-ray pictures of the females.

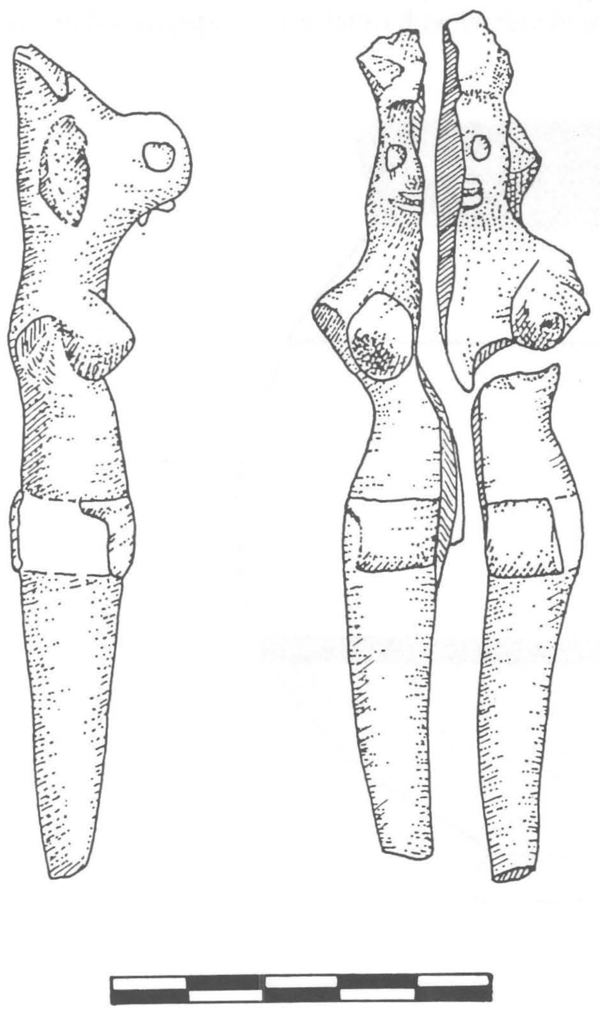

Figure 5.5: Harappan phase female figurine from Harappa showing that the body of the figurine was made in two halves that were later joined; H87-253/11-50 from debris covering Harappan phase cemetery (R37).

Is this practice peculiar to Harappa? One certainly might expect to see similar figurines at Mohenjo-daro. But none of the female figurines I excavated there in 1964-1965 show this manufacturing technique, nor is any mention of such a manufacturing practice found in the reports by Marshall or Mackay of their excavations at the site. There is, however, one fragmentary but clear example of a split body figurine illustrated by Mackay (1938: Pl. LXXII, 5 and 6), although in his discussion (1938: 271), he makes no comment on the fact that the torso is split in half vertically. This figurine comes from the upper levels of Area DK-G. Instead of (or in addition to) differences between sites, could it be that there is a chronological factor involved here, with female figurines of the later part of the Harappan phase (well represented at Harappa in the fill above the Harappan graveyard) being made using the split body technique? This hypothesis will be tested as the contextual study of the artifacts from Harappa continues.

The second example of idiosyncratic practices in forming anthropoid figurines at Harappa may be easier to explain, although without contemporaneous written documents of a religious or ritual nature, we will never be able to understand its true significance for the ancient Harappans. Again, it was during the tabulating of the figurine fragments that we noticed something peculiar about the upper torsos of the female figurines. The arms do not break off irregularly from the bodies but rather become detached, leaving neatly formed shoulder joints. The concave half of the joint is seen at the top of detached arms and the ball of the socket joint is preserved as a small conical projection on the shoulder (Figure 5.6). Even though this is opposite to the humerus-scapula joints in real humans where the glenoid cavity on the scapula articulates with the semi-spherical head of the humerus, the imitation of anatomical detail in the figurines is nonetheless convincing. After the figurine makers attached the arms to the torso, they applied a rectangular strip of clay over the top of the joints to cover them, like skin.

An explanation for the reversal of the anatomical components of the shoulder joints may be seen in the torsos of the figurines when the arms are detached. The unembellished torso is nothing more nor less than a stylized trunk of a body used for millennia by figurine makers going back through time and space across Central Asia and the Near East to the

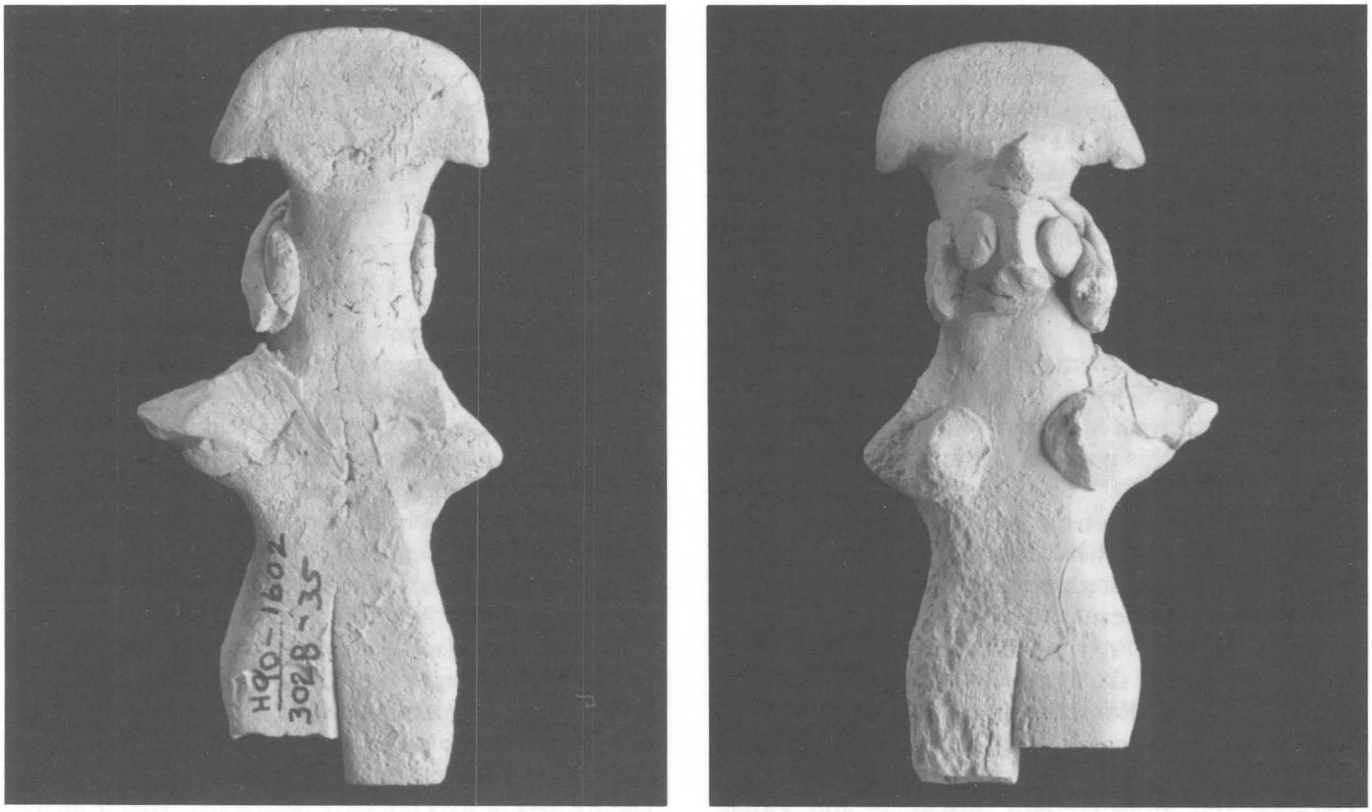

Figure 5.6: Harappan phase female figurine from Harappa showing how the limbs were joined to the body; H90-1602/3028-35.

Mediterranean and eastern Europe (Figure 5.7). These minimal representations, often headless and legless, expressed femaleness; if breasts were portrayed, they were formed as part of the torso and not applied.

The Harappans, on the other hand, adopted this most basic of human torsos and "created" a more naturalistic human female form by the applications of separately made parts. We can only speculate, but it is conceivable that ritualistic "creation" or birth was the *raison d'être* for making the female figurines at Harappa. Further excavations might yield more information on such practices, and closer examination of female figurines from other Indus sites may find evidence for similar figurines that heretofore have gone unnoticed.

Stoneware Bangles

The Harappans manufactured some of the world's first stoneware in the sense of a very dense, impermeable, homogeneous, siliceous ceramic (Vidale 1990). The ceramicist Bernard Leach states that the word stoneware "is appropriate enough, for it suggests the quality of melted stone" (Leach 1976: 36). The most

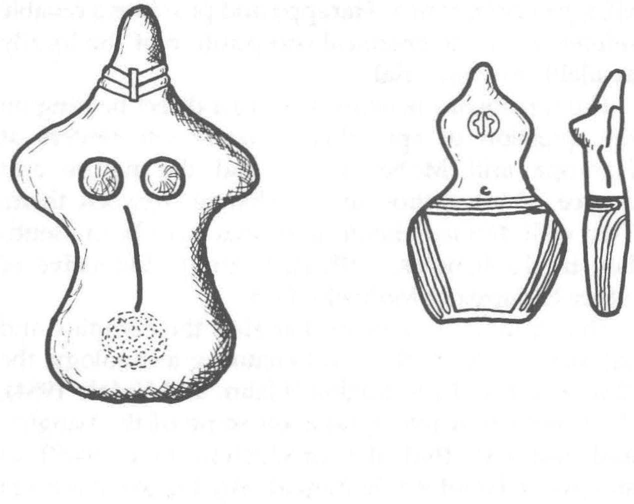

Figure 5.7: Figurines from western Asia: left—Tal-i Bakun, southern Iran; right—Tepe Gawra, Iraq, Halaf Period.

similar ancient product, according to David Kingery (personal communication) who has examined some of the Harappa samples, is probably the dense black stoneware made in China during the Han dynasty some two millennia after the Harappan period. Leach (1976:28) also attributes the invention of stoneware to early China, between the second and sixth centuries BC.

These exceptionally high quality bangles have been reported from both Harappa and Mohenjo-daro by the earlier excavators. Marshall (1931:530, 686) had tests run on samples from Mohenjo-daro, but until recently no one had studied them systematically. Such studies began with the German-Italian Research Project at Mohenjo-daro, with Massimo Vidale taking a particular interest in this material (Halim and Vidale 1984; Vidale 1987, 1990). Now, thanks to cooperative research programs between the Harappa project, the Conservation Analytical Laboratory (CAL) of the Smithsonian Institution, and members of the Mohenjo-daro project, significant progress is being made in the analyses of specific products such as stoneware. Massimo Vidale of the Istituto Italiano per il Medio ed Estremo Oriente (Rome) and M.J. Blackman of CAL have collaborated on making comparative chemical characterization studies of stoneware bangles from Harappa and Mohenjo-daro (Blackman and Vidale 1992).

The chemical analysis of the bangles was carried out by instrumental neutron activation analysis (INAA). Twenty-nine elements were sought, twenty-two of which were used in the comparative studies. In addition to the ancient bangle samples, a single modern bangle replica made at Harappa by J.M. Kenoyer, using clay from the Ravi river beds near the site, was also analyzed. This same clay is nowadays used by a village of potters near Harappa and provides a reliable reference for the chemical composition of the locally available raw material.

The results of the analysis have a direct bearing on the question of specialized production centers at Harappa and Mohenjo-daro and the nature and degree of interaction and exchange between them. Two well defined chemical groups have been identified in the bangles, with each group distinctive of either Harappa or Mohenjo-daro.

The rarity of stoneware bangles, the complex and singular nature of the manufacturing technology, the strict control of production (Halim and Vidale 1984), the presence of inscriptions on some of the bangles, and the fact that the production (and use?) of stoneware bangles is known at only the major sites of Harappa and Mohenjo-Daro, suggest to Blackman and Vidale (1992) that the bangles had a unique social function. Also, the fact that bangles identified as having been manufactured at Mohenjo-daro are found at Harappa, but bangles produced at Harappa have not been identified at Mohenjo-daro, suggests some type of special exchange system and even a special relationship for Mohenjo-daro *vis-à-vis* Harappa.

Specialized studies such as these are providing unexpected new information concerning various important aspects of Harappan society.

Faience

Faience is the name most commonly applied to ceramics made of ground quartz sintered with alkali-lime glassy bonding material and colored by the use of alkali-lime glazes (McCarthy and Vandiver 1990). The earliest known production of faience has been identified in Badari, Egypt, about 4,000 BC and shortly afterwards in northern Mesopotamia at the sites of Tell Arpachiyah and Tell Brak. Faience objects at these sites—mostly beads and small amulets—seem to have served as prestige items for the social elite.

Faience was also a major production item in the Indus civilization some 1,500 years later. Bangles, beads, rings, amulets, inscribed tokens, tiny figurines of animals, stamp seals, and small vessels have been excavated at Indus sites. The technology for making faience may or may not have been transferred from the Near East to South Asia over the intervening centuries, but the significant fact is that comparative studies of samples from both regions show clearly that the Indus faience is different in terms of its dense microstructure, its strength, and overall uniformity of color (McCarthy and Vandiver 1990).

These conclusions are based on laboratory analyses of 21 faience samples excavated at Harappa during the 1986-1988 field season plus three samples from the Indus site of Chanhu-daro in the collections of the Museum of Fine Arts, Boston. A detailed report on the analyses was presented at the 1990 Annual Meeting of the Materials Research Society (McCarthy and Vandiver 1990).

The Indus faience technology is also an important research interest of J.M. Kenoyer as part of his broader interest in Harappan craft activities. He has conducted studies at CAL that complement those of McCarthy and Vandiver (Kenoyer 1990) and is continuing laboratory studies at the University of Wisconsin, Madison, on a larger group of samples.

Concluding Remarks

Even these brief descriptions of four of the most important categories of ceramic production at Harappa show the high level of sophistication of Harappan pyrotechnology and craftsmanship. We have already made significant advances in technological studies, but

ceramic studies at Harappa are going well beyond typologies, chemical characterizations, and chronological sequences. Distribution patterns, contexts, and associations with other categories of artifacts are subjects of major importance in our search for a more accurate and sensitive understanding of the technological and artistic achievements of the Harappans and how they influenced, and were influenced by, different aspects of the socioeconomic and cultural systems.

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Cover art: Bowl on Stand H88-1002/192-17 associated with Burial 194a
in Harappan Phase Cemetery (see Figure 13.18).

6

Patterns of Technology and the Organization of Production at Harappa

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Following a brief discussion of the regional and inter-regional contexts in which Harappan pottery production took place, focus is placed on recent excavations at Harappa for the purpose of providing an introduction to the project with respect to patterns of technology and the organization of production. Evidence for specialization, standardization, and control in pottery manufacture at Harappa is evaluated. Specialization can be inferred from the restricted range of types produced in the context of a single activity area, from repetition of patterns of technology in the production process, and from the high degree of efficiency in production and in the multiple sequences employed. The high level of skill of the potters is revealed in the quality of the final product, in the patterned sequences, and in the tools they employed, while standardization is evident in the restricted range of forms produced in uniformly applied production sequences. Evidence for central organizational control over pottery production, however, is largely lacking. These features taken together with evidence from other crafts and other sites show that different kinds of production were absorbed into the Harappan urban environment in different ways. The evidence reviewed also suggests that kinship groups in the Harappan civilization continued to exist as viable political and economic entities, a situation that confirms what we know from other urban contexts.

Integral to the study of ceramics at Harappa (Dales, Chapter 5 in this volume) is research designed to reconstruct the technical features of pottery production. In doing this, we have in mind several objectives relating to chronology, production, and exchange.

First, we are identifying technological attributes for each of the defined pottery types. This aspect of the study follows the model previously developed by Dales and Kenoyer (1986) for Mohenjo-daro but expands it to include more detailed laboratory analyses. The approach used is to define structural properties and elemental components in order to reconstruct the production sequences for each type, i.e., refinement and handling of clays, forming processes, secondary treatments, components of decorative paints, firing temperatures and atmospheres. Such an integrated approach promises to permit us to refine our relative chronology.

Second, the typological/technological sequence promises to facilitate comparison between sites within the Harappan civilization and with non-Harappan groups with which it came into contact. The major questions here are exchange related, i.e., to determine whether specialized technologies were widely shared —suggesting communication among crafts people, whether the objects themselves were exchanged, or whether both occurred. The results of a refined typological/technological analysis will form the basis on which to make determinations of which settlements may have been involved in such inter-regional networks.

Third, we are correlating the results of the technological study with different activity areas within the site. This approach permits us to determine whether specific technologies are associated with particular activity areas and provides a basis on which to make inferences on how production was organized. In urban environments such as Harappa, where the areal extent of the site is estimated at 150 ha. (Dales and Kenoyer 1990) and where the population in some phases of the city's development may have been as high as 50,000, one might expect, based on more general conceptions about urbanism, that the

organization of craft production shifted from small-scale to larger-scale units, from residential to separate workshops, and from domestically controlled to administratively controlled production. Thus Vats (1940:58) identified as "Workmen's Quarters" the remains of 14 houses and manufacturing installations that he excavated in Mound F of Harappa. He based his interpretation upon the uniformity of the structures and their association with a metal working area and suggested that at least some crafts were linked to administrative control. Whether or not Vats possessed sufficient evidence on which to base his identifications may be contested; nonetheless, they remain a legacy upon which syntheses of the evidence for the Harappan civilization have been based. Wheeler (1972:31-32), for example, described the same structures as "ranges of barrack-like quarters" and "a piece of government planning," and others have compared them to "artisans' or slaves' quarters in such sites as Tel-el-Amarna" in New Kingdom Egypt (Allchin and Allchin 1982:183). Thus the nature of the organization of production and its relationship to urbanism and state formation remains an issue of major importance in Harappan studies.

Finally, these results will be combined with studies of other crafts being carried out by members of the Harappa team, such as metallurgy, other forms of pyrotechnology, bead making, and weaving. Conceived of as a whole, comparisons of the technical properties of crafts, the organization of individual crafts, and the extent of their distribution will provide information on how different crafts were absorbed into the administrative system at Harappa.

Obviously these goals can only be realized in the long-term, and in this paper, I can approach just some aspects of them. In what follows, I provide a brief background to issues of relevance to Harappan pottery production and then focus on recent excavations at Harappa. Its purpose is to provide an introduction to the project with respect to patterns of technology and the organization of production and to discuss some preliminary findings.

The Harappan Pottery Assemblage

As is well known, by the mid-third millennium BC and extending at least to its end (Shaffer 1991:448), the Harappan civilization coexisted with several other major civilizations. A map of the Middle East during this period shows a succession of cultural groups that extended on the west from the Old Kingdom through the First Intermediate Period in Egypt (Kemp 1989:14); late Early Dynastic, Akkadian, Ur III, and possibly Isin-Larsa in Greater Mesopotamia; and the Namazga IV–V periods in Central Asia (Amiet 1986:12). In addition to these major civilizations, other smaller, less well-known groups in the Arabian Gulf region were contemporary with the Harappans. Recent excavations there, in the United Arab Emirates (Cleuziou 1982; Frifelt 1975; Potts 1990) and the Sultanate of Oman (Cleuziou and Tosi 1989; Weisgerber 1980, 1981), have revealed a uniform material culture during the third millennium BC.

The Harappan civilization had developed wide-ranging trade relations, the scale of which was sufficient to suggest that it participated in a "world economy" (Lamberg-Karlovsky and Tosi 1973; Kohl 1979; Lamberg-Karlovsky 1989). Contact, for example, had clearly been established with Mesopotamia and possibly with Central Asia, although probably not with ancient Egypt. In addition, a growing body of archaeological evidence of typical Harappan materials such as standardized weights, etched carnelian beads, and selected pottery types, (Cleuziou and Tosi 1989:40; deCardi 1988:Figure 14:22; Potts 1990:43) attests to contacts between the Harappans and the inhabitants of the Gulf region.

In many earlier publications it had been noted that the pottery assemblage for the Harappan civilization was relatively homogeneous and standardized. This original conception has generally held up in spite of the excavations at a number of new sites. In the most recent synthesis of the chronology and material culture for the Harappan civilization, Shaffer (1991:448) characterizes Harappan pottery as possessing "a basic homogeneity throughout its distribution." Although present principally in the alluvial plain of the Indus valley, it also occurs at sites more broadly distributed and less well known in the literature. This distribution includes a territory that extends far to the north in Afghanistan and south to the Arabian Sea, including most of Pakistan and parts of India. Among the more recent excavations are those at Shortugai, (Francfort 1989), Rehman Dheri (Durrani 1988), Nausharo (Jarrige 1986, 1988), Ghazi Shah (Flam 1992), Allahdino (Fairservis 1982) and Balakot (Dales 1974, 1979).

The evidence for Harappan-related pottery at sites in the Gulf region is more limited in the range of types present. They include decorated wares (deCardi 1989: Figure 2; Cleuziou and Tosi 1989: Figure 10; dish-on-stand: Figure 11.3-5; large storage jars: Figure 11.1,2; and possibly Potts 1990:Figure 28.5). These Harappan-related types are different from locally produced pottery at Gulf sites, suggesting that Harappan pottery may have been imported, either for the objects themselves or for their contents.

This introduction provides some of the background to the regional and inter-regional contexts in which pottery production took place. However, these

systems of distribution operated within the context of locally organized production systems. In the remainder of the paper, I focus on the context of production at Harappa.

Foundations for the Study of Production

The excavations at Harappa provide an opportunity to examine the relationship among the transformative processes of urbanism, state formation, and the organization of production. There is the expectation that, with the increased availability of resources and technologies to utilize them as societies become more technically sophisticated and establish exchange relations, the division of labor within a society will become more complex. In prehistoric urban environments, for example, it is widely believed that specialist producers dominate particular technologies. A major characteristic of urbanism itself, according to V. Gordon Childe (1950), is the aggregation of specialists, both subsistence and craft-related, within the context of densely populated settlements. Social differentiation occurs as sectors of specialization develop. However, major structural differentiation and advances in social complexity are the result of the implementation of power by elites and interest groups as they attempt to control production and distribution systems. The implementation of power, whether socially, politically or economically motivated, thus plays an important role in the form that the organization of production takes.

There are a number of assumptions that underlie the expectations outlined above. Most are rooted in one or a combination of Marxist and neo-classical economic theory and in the evolutionary formulations elaborated upon by Fried (1967), Service (1971), Steward (1955), and White (1959) in the anthropological literature. Basic to each is the importance accorded to the acquisition of specialized knowledge and the limitations of accessibility to that knowledge or the products generated by it. Indeed, production systems are interesting because they represent potential arenas or opportunities for control by a variety of interest groups. In state level societies, it is assumed that one of the ways in which elites acquire and maintain their status is through the appropriation of products and the labor of producers who possess specialized knowledge. Evolutionists such as Service assume an integrative advantage to dominance by elites who sponsor crafts and organize redistribution systems, while others, such as Fried assume an adaptive role for the society in the control of heterogeneous groups that are potentially disruptive to that society. Steward's ecological model also is dependent upon evolutionary theory, but accounts for variation by noting ecological constraints that affect choices in the allocation of resources and labor. Although elements of efficiency are at issue in the cultural ecological model, least-cost concerns are most pronounced in systems analysis. White, for example, borrowing a thermodynamic model, emphasizes the relationship between increasing efficiency, harnessing energy, and the development of complex systems.

As general concepts, each of the above provides a useful framework but is limited because of a strong adaptive bias and a failure to account for the different ways in which control and power are implemented. Power is relevant because its implementation involves a multiplicity of countervailing forces that are social, political, and economic in nature and affect how the control of production systems manifests itself. In other words, the organization of production systems and the development of complex social structures are dependent upon a variety of strategies and interest groups that attempt to maintain or control them, since attempts to mobilize resources by elites or interests groups are subject to challenges and factional interests. As Wolf (1990:590) has put it, "organization is always at risk. Since power balances always shift and change, its work is never done." In implementing power, tactical solutions are critical because they play an instrumental role in shaping organizations, maintaining them, and establishing them. Indeed, organization structures the field of action so that some behaviors are possible, while others are less possible (Wolf 1990:586ff.).

Power, therefore, and the nature of its implementation differ in different cultural contexts. This is the case because power and its implementation are socially defined actions played out within the constraints of culturally-defined acts of rationality. It follows, therefore, that advances in technology and knowledge are not in and of themselves the causes of craft specialization, greater complexity in labor organization, and urbanism as Childe believed (Trigger 1980:145), but they are made so (shaped) by elites and other interest groups in projects initiated by them (McGaw 1989; Rueschemeyer 1986). Understanding the specific processes through which the division of labor and its elaboration into complex forms of organization take place, therefore, requires "processual detailing" (Rueschemeyer 1986:193) to reveal how power takes hold in particular social and cultural settings. While we can reasonably assume that advancements in technology and increasing specialization provide opportunities for the take-over of its organization, we also must assume that competition among interest groups will affect the particular type of organization of production that occurs. Its

outcome is not pre-determined by technological advance or increased specialization.

This kind of processual detailing has already begun on the organization of production in the Harappan civilization, and the evidence shows considerable variability. As noted above, the interpretation of evidence from previous excavations suggests that at Harappa the organization of production, at least of some crafts, is based on administrative control. If this assertion is correct, it suggests that the organization of production changed between the Early Harappan and "mature" Harappan phases. At the site of Mehrgarh, for example, production during the Early Harappan phase is found within the context of domestic courtyards, suggesting that production was organized by autonomous, independent groups, perhaps on a kinship basis (Wright 1984). The picture is less clear when it is compared to results from the site of Mohenjo-daro. At Mohenjo-daro early excavations had revealed pottery production in large industrial compounds (Mackay 1938:6) and in small isolated units (Marshall 1931). A recent re-evaluation of this evidence based on surface surveys (Pracchia et al. 1985), in which distributional maps of production areas have been outlined and associated archaeological indicators tabulated, confirms the presence of both types of installations. The industrial compounds appear to be part of a post-urban occupation, however, and confined to the production of a single type, the so-called "Indus goblet" (Vidale 1989:178). They are also substantially smaller than Mackay had believed; the area has been subjected to extensive post-depositional processes, and a current estimate of its size is "below the 1200 sq m of the surface spread" (Pracchia et al. 1985:242). The small, isolated units are found both within dwelling units (Vidale 1989:178) and apparently not in dwelling units but in disaggregated ones associated with production of other crafts (Pracchia et al. 1985:224 and Figure 1). The latter have been interpreted as "small manufactures and distribution units in shop-like arrangements" akin to an "oriental bazaar" in which the city's authorities "monitored allocation of space of craft activity" (Pracchia et al. 1985:242). If all types of crafts are taken into account, the size of the production units is on "average" 25-30 sq m, while "60% of the detected units are smaller than 100 sq m" (Pracchia et al. 1985:241).

Although subject to re-evaluation, we now have documented three types of craft producing units. One type consists of larger units. At Harappa, such units are associated with an area in which administrative activities are present; at Mohenjo-daro, they are associated with post-urban encroachment in formerly residential areas the control of which is undetermined. A second type at Mohenjo-daro is small in scale and associated with dwellings, suggestive of household production units. A third type at Mohenjo-daro also is small in scale, but is located on the periphery of the city in areas apparently allocated to craft activities. In spite of the interpretation that this production was in some way monitored by the city's authorities, there is little direct evidence of administrative control, except in the highly specialized manufacture of stoneware bangles, where seal impressions were found on saggars (Vidale 1989:178). Thus the available evidence indicates that a variety of groups may have been involved in the control of production.

In view of this variability, we have defined our terminology as broadly as possible to account for the implementation of a variety of organizational strategies. At the same time, we have attempted to build on the database established from the Mohenjo-daro surface surveys, modifying them to accommodate the finer chronological control possible in excavations and the possibility of monitoring changes through time. Therefore, we have viewed the evidence from Mohenjo-daro and earlier reports from Harappa as propositions to be tested against the results of the renewed excavations. The following discussion outlines the types of factors considered and the archaeological indicators we have selected.

Patterns of Technology and Organization of Production

A number of factors are integrally related to assessing the types of production units present and changes in the organization of production, but three form the center of our research–specialization, standardization, and control.

Specialization, Standardization, and Control

Specialization and standardization are routinely applied criteria in studies of the organization of production (for example, see discussions by Feinman et al. 1984; Rice 1981; Sinopoli 1989). They may be measured and assessed against the archaeological evidence through a variety of means (for example, Arnold 1985; Feinman et al. 1984; Rice 1981; Tosi 1984). Occupational specialization, as it is used here, is manifested in the archaeological record by evidence for patterned sequences of technology carried out by a restricted number of producers in the context of concentrated and sustained production. In addition, these patterned sequences imply a level of complexity related to skill. Specialists can be part-time or full-time (Wright 1983; Kaiser 1984), be present in small-scale or complex societies, and be independent–producing for an "unspecified demand crowd" as Brumfiel and Earle

(1987:5) have suggested–or attached–producing for a patron, i.e., an individual or government. Thus occupational specialization is a necessary but not a sufficient requisite to control by a centralized bureaucracy, since if we assume competing groups will attempt to take over or retain control of specialists and their products, the outcome may vary. Control by elites is one solution to a much broader range of possibilities as systems of specialization develop. Thus they may include a range of organizational types from household or family and kinship based to centralized or state controlled.

A corollary to specialization is standardization. It follows from the above definition that the application of specifically patterned sequences of production (whether consciously or unconsciously applied) may result in standardization of final products. Standardization is relevant because it involves repetitive behaviors which may be designed to maximize output and minimize production and labor costs (Sinopoli 1989:263). In technical studies, these factors are assessed through production step measures (Feinman et al. 1984) and other measures of labor investment (Costin et al. 1989:119). However, while there clearly is a link between standardization, patterning of sequences and least-cost strategies, it is doubtful that these factors are the concern of large-scale bureaucracies alone but equally affect independent, small-scale producers. Moreover, given that the implementation of power does not necessarily operate within the context of universally determined measures of adaptive behavior, it is doubtful that efficiency or factors of least-cost, also socially-defined phenomena, necessarily imply centralized or bureaucratic control. Thus in studies of production systems, they can only represent an "ideal," since ideas about efficiency are not homogeneous across social groups.

The third factor, control, is the single most decisive factor because it most directly reflects the organization of production. It also is the most difficult factor to assess, since it relates to complex social relationships not easily identifiable in the archaeological record. In civilizations such as the Harappan in which a writing system, seals, and other record-keeping devices have been found, we should expect to see them in evidence where production is administratively controlled. Record-keeping devices are a universally applied criterion as a direct manifestation of the control of production. As with any measures, they may require re-evaluation in the future, but here I have included them as a primary indicator of control. A second measure, developed by Tosi at Mohenjo-daro and elsewhere (Tosi 1984) is designed to combine evidence for numbers of production sequences performed on objects with the size and output of activity areas. He designates his four types as follows: 1. Atelier–small with limited production sequences and low *per capita* output, not to exceed 2% of small sites; 2. Workshop–small with broad spectrum of production sequences and a "significant portion of a small site" Tosi 1984:24); 3. Factory–large with limited production sequences of a single product, and extensive facilities; 4. Craft quarter–large, several different crafts in close proximity, high per capita production, occupying "a significant percentage of large sites (10-25%)" (Tosi 1984:24).

Using the above discussion as a foundation for the study, I have outlined below two sets of archaeological indicators for the Harappan data. The first outlines general archaeological indicators of craft production and the second lists factors specific to patterns of technology and the organization of production of pottery.

Archaeological Craft Indicators

Raw materials
Tools
Fixed installations
Debris (discard/recycle)
Finished/unfinished products

Organization of Production

Context	–	Residential workshop Separate workshop
Scale	–	Production sequences Producer indicators Single product Multiple products Output %Occupied space
Record keeping	–	Seals Tokens Standardized graffiti Sealings Weights/measures

Organization of Production

The three factors–context, scale, and record-keeping devices–are identified as follows. Context is a physical or spatial factor and refers to architectural or other features with which production is found in association. There is a range of possibilities that reflect on social relations among producers, and although many typologies have been developed (for example, van der Leeuw 1977, 1984; Peacock 1982; Rice 1987:184), here I have followed Stark (1985) in defining two types, namely, residential workshop versus separate workshop. I have chosen this simplified typology since it is

not encumbered by social equivalents and have used it to create preliminary categories for later assessment against those developed by Tosi and others at Mohenjo-daro (Pracchia et al. 1985). A residential workshop simply refers to a physical location in a domestic area; a separated workshop is not integrated into a domestic area (Stark 1985:160).

Scale refers to output in the production process, i.e., numbers of producers and products, and is based on the analysis of artifacts associated with the production process itself. It includes the number of production sequences or manufacturing operations performed on a single product. Production sequences are reconstructed through analyses of the products themselves and are suggestive of patterns of technology and their transmission, relative amounts of labor expenditure, and participation by an individual or several crafts people in a particular craft activity. Producer indicators refer to more direct indicators of relationships among producers. This aspect of the study combines the results of production sequence data with a program of finger and palm print analysis. Because of the nature of the pottery production process, many finger and palm prints have been preserved on pottery (as well as other terracotta objects such as figurines and bangles) and on potter's tools. Recent studies suggest that given a sufficiently large sample, it may be possible to identify gender and genetically-based similarities (Babler 1979; Chai 1971; Okajima 1978). Through this combined process it may be possible to identify individual potters groups, their gender, and genetic relationships. Single vs. multiple producers simply refers to whether one type of product is being produced in a given location or several to determine whether craftsmen specialized in one type of material and/or whether they produced specific types of products in a given craft. Output is a measurement based upon the amount of debris, unfinished products, secondary materials such as fuels, and the percentage of occupied space relative to other activities.

Record-keeping devices refer to tokens, seals, sealings, script, and weights or measures (for examples, see Jarrige 1988:158ff.). These items represent a series of standardized objects present throughout the Harappan civilization, but most prominently at urban sites. In view of their standardization and their association with a well-developed script, they have been closely linked with administrative control. In previous research, record-keeping devices have been associated with pottery production in three ways. At Mohenjo-daro, Indus goblets were found with seal impressions on their exterior surfaces (Jarrige 1988:163), the saggars used to fire the stoneware bangles produced at Mohenjo-daro also are seal- impressed (Halim and Vidale 1984), and occasional sherds and whole vessels on a restricted range of forms have Harappan script inscribed on the fired vessel. Examples have been found both at Mohenjo-daro (Dales and Kenoyer 1986) and at Harappa.

Excavations at Harappa

The excavations of the University of California, Berkeley, team must be understood within the context of previous work conducted at Harappa. This context is outlined by Possehl (Chapter 2 in this volume), described by Kenoyer (Chapter 4 in this volume) and shown on Figure 6.1. Here, I review some specific aspects of previous excavations on Mounds AB and F relevant to the organization of craft production and its control.

The major mound at Harappa, Mound AB, partially excavated by Sahni (1920-21), Vats (1940), and Wheeler (1947) in the first half of this century is an area consisting principally of large public structures. In addition, Wheeler (1947) identified a massive brick structure that appears to have defined the outer limits of the mound. Although it is unclear whether this structure was subjected to one or a series of rebuilding phases and although its initial construction phase is in doubt (see Kenoyer, Chapter 4 in this volume), there does appear to have been an effort to isolate the mound, at least visually, from others contiguous to it during some periods of habitation.

On Mound F, Vats (1940:17ff.) reported a series of structures that he associated with administrative functions. They include a large building that Vats identified as a "granary," several other large buildings that he referred to as "residential," twelve circular platform structures, the 14 "workmen's quarters" referred to earlier, a metal working kiln, and associated debris.

Mound E, unexplored previously, has been the focus of excavations during the past several seasons. It lies directly east of Mound AB and was occupied from the Early Harappan (Period 1) through the Late Harappan (Period 5). Two sections of Mound E have been excavated and have yielded different types of activities. In the southern portion, dwellings, streets, and a major circumvallation have been uncovered. Numerous record-keeping devices were found in the street and dwellings. Thus far we have not found any *in situ* evidence for craft production in this part of the mound. In the northwest section of the mound, we have located a sizable area in which pottery production was carried out during Periods 2 and 3. The remainder of this paper is devoted to a discussion of this production area.

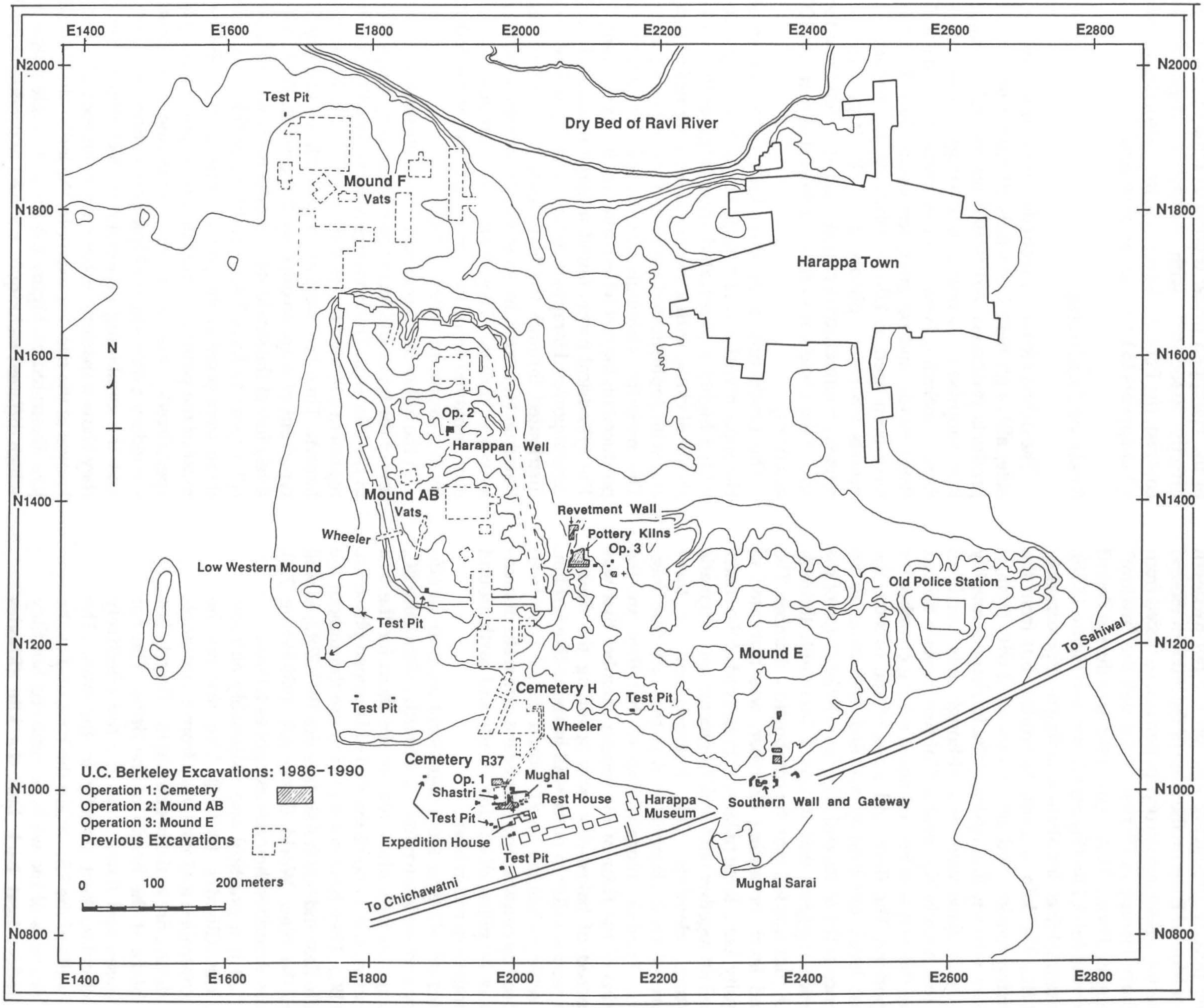

Figure 6.1: Map of Harappa showing extent of previous and current excavations.

Context of Production

The pottery producing area on the northwestern side of Mound E sits on the edge of the modern mound in a sector where human occupation can be traced from the Early Harappan (Period 1) through the "mature" Harappan (Period 3). A focus of the area during Period 3 is a mud-brick kiln (Figure 6.2; see also Figure 13.28), a substantial fixed installation, dating to approximately 2300 BC. The kiln is partially eroded, but from the surviving remains and debris associated with them, it appears to be a typical updraft kiln. Its shape is roughly circular in plane view and, although only one level remains, it probably consisted of two levels–a firebox where the fuel was burned and a setting chamber for the pottery. The floor and sides of the firebox, the lowest level, are heavily vitrified and taper to an entrance at the south end. The funnel-like shape of the entrance suggests that it was a firemouth through which fuel was fed into the combustion chamber. The second level, or setting chamber, was truncated in antiquity, but a large pillar was preserved at the center of the kiln together with wall fragments and enigmatic structural elements. One interpretation of these concave-shaped elements is that they are flue fragments. Another interpretation is that they are the remains of the floor of the setting chamber that was composed of baked-clay bars spanning the firebox from central pillar to outer wall in spoke-like fashion. The setting chamber itself would either have been enclosed by constructing permanent side walls of mud-brick or by piling discarded sherds and earth around the pottery to retain heat.

Kilns of this type are a significant advance in efficiency and are known from the fourth millennium BC, although in the Indus area we see them for the first time toward the end of the Early Harappan phase (ca. 2500 BC). They have continued in use throughout the Middle East and South Asia (Rhodes 1981:17ff.), as well as in the New World (Papousek 1989:Figure 7.1). Rhodes describes their advantages as follows:

> ...it is a practical and reasonably efficient kiln...(Rhodes 1981:16). The fire can be controlled and may vary from a low smoldering fire at the beginning to a fiercely hot blaze at the height of the firing. The hot gases and flame from the fire effectively circulate heat directly to the ware. The walls of the kiln retain the heat, and as the surfaces of the walls become red hot they reflect heat back into the kiln (Rhodes 1981:22).

Two other kilns are present in this area of Mound E (Figure 6.2). A smaller pit kiln to the southwest is contemporary with or slightly earlier than the updraft kiln and is less well preserved, and another pit kiln is present in the immediately preceding Period 2. Neither of the Harappan phase (Period 3) kilns appear to be directly associated with habitation deposits. In contrast, the Period 2 kiln is in direct association with what appears to be a residential structure.

Scale of Production

The debris recovered from the kiln area is considerable, although here I can only discuss a few of the products produced. Artifacts from around the large kiln comprise numerous objects suggestive of manufacture, including bone spatulae, chert blades, a chuck (base mold), and irregular terracotta slabs that may have been used as kiln furniture or as supports for vessels when in a pliable state. The large kiln was reused on numerous occasions and, depending on the size of the vessels, may have contained as many as 200 at a firing.

The production techniques known by potters at Harappa reveal a technology suggestive of potters with a highly sophisticated knowledge of the workability of clays, with a variety of forming techniques, and with sophisticated methods for combining them. The majority, although not all, of the pottery is produced on the fast wheel, much of it "on the hump." The cylindrical forms found in large numbers in the contemporary Harappan cemetery (R37) and widely distributed through the Harappan civilization illustrated on Figure 6.3, for example, are readily identified as wheel thrown. They were raised from lumps of clay, removed from the wheel, and not subjected to further treatment before firing.

In the following discussion I have illustrated only a few of the types and techniques utilized by the potters in the kiln area. The ceramics associated with the kiln represent a limited range of the types and technologies known. Thus far, we have been able to identify 12 types out of a approximately 200 overall. First, relatively few of the single stage products shown in Figure 6.3 appear to have been produced in this area, and there were none of the pointed base goblets. Rather, most of the pottery in the kiln area represents highly specialized manufactures, requiring elaborate secondary processes, multiple production sequences, and the combining of numerous techniques. Thus, they show a mastery of the most complex techniques known at the site. For example, the ledge-shouldered jars illustrated on Figure 6.4 show a single shape in which different techniques are used to produce a final product. These vessels first were drawn on the wheel (Figure 6.4a), subsequently trimmed to their maximum body diameter, covered with a cream colored slip (Figure 6.4b), and scraped in horizontal and diagonal striations in a final step before firing

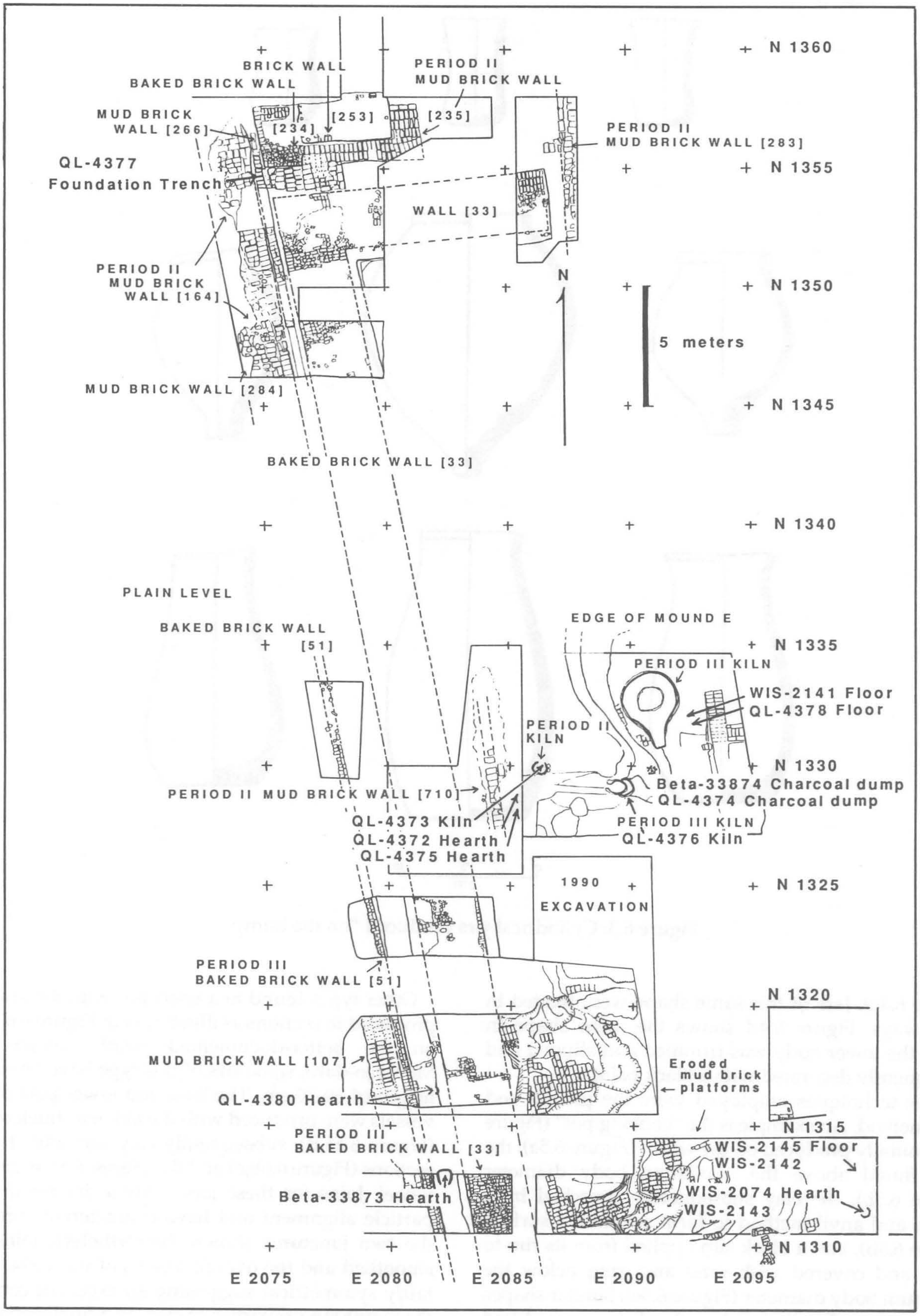

Figure 6.2: Map of northwest corner of Mound E showing location of Period 2 and 3 kilns.

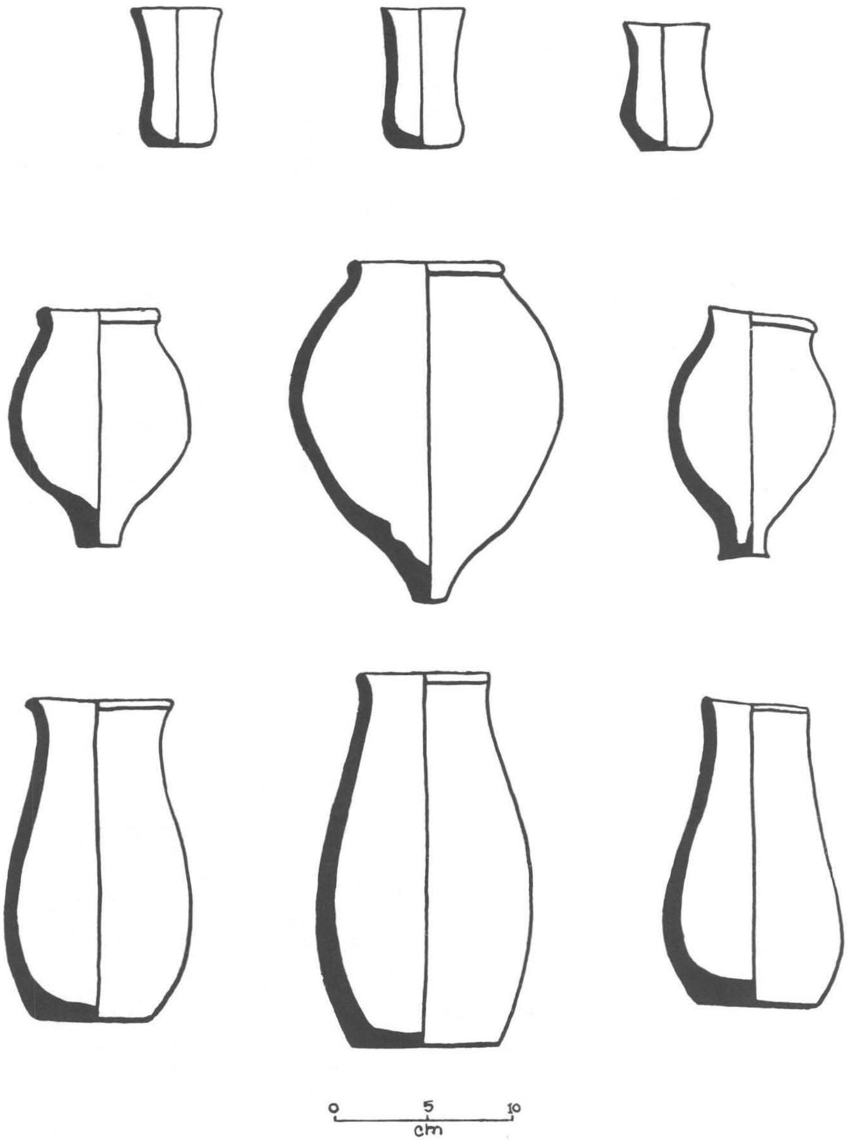

Figure 6.3: Cylindrical jars produced "on the hump."

(Figure 6.4c). Jars of this same shape were treated in other ways. Figure 6.4d shows the same shape in which the lower body was trimmed and slipped and subsequently decorated with a black paint.

Other techniques employed were the paddle and anvil method. An example is the "cooking pot" (Figure 6.5c), initially produced on the wheel (Figure 6.5a), the sides fluted above the maximum body diameter (Figure 6.5b), the clay subsequently stretched by a paddle and anvil method to form a rounded surface (Figure 6.5b), and a black slip applied from its rim to flange and covered with sand and grog below the maximum body diameter (Figure 6.5c). Similar shapes simply were fluted, leaving the base unmodified (Figure 6.5d).

Other types found in association with the kiln were produced in sections as illustrated in Figure 6.6. Based on the better-documented whole vessels from Mohenjo-daro, some jars of this type have an external height of 60-70 cm. The base and lower part of these vessels were produced with the aid of a chuck or mold (Figure 6.6a,d); subsequently clay was added in two sections (Figure 6.6b,e) and the pieces drawn up on the wheel. Joins for these jars show a disorientation of particle alignment and have characteristic breaks at the two junctures shown. Nevertheless, joins were smoothed and the overall shapes of the vessels were fairly symmetrical suggesting an excellent control of the shrinking properties of clay. In a final step the jars were coated on their interior with a thick red or

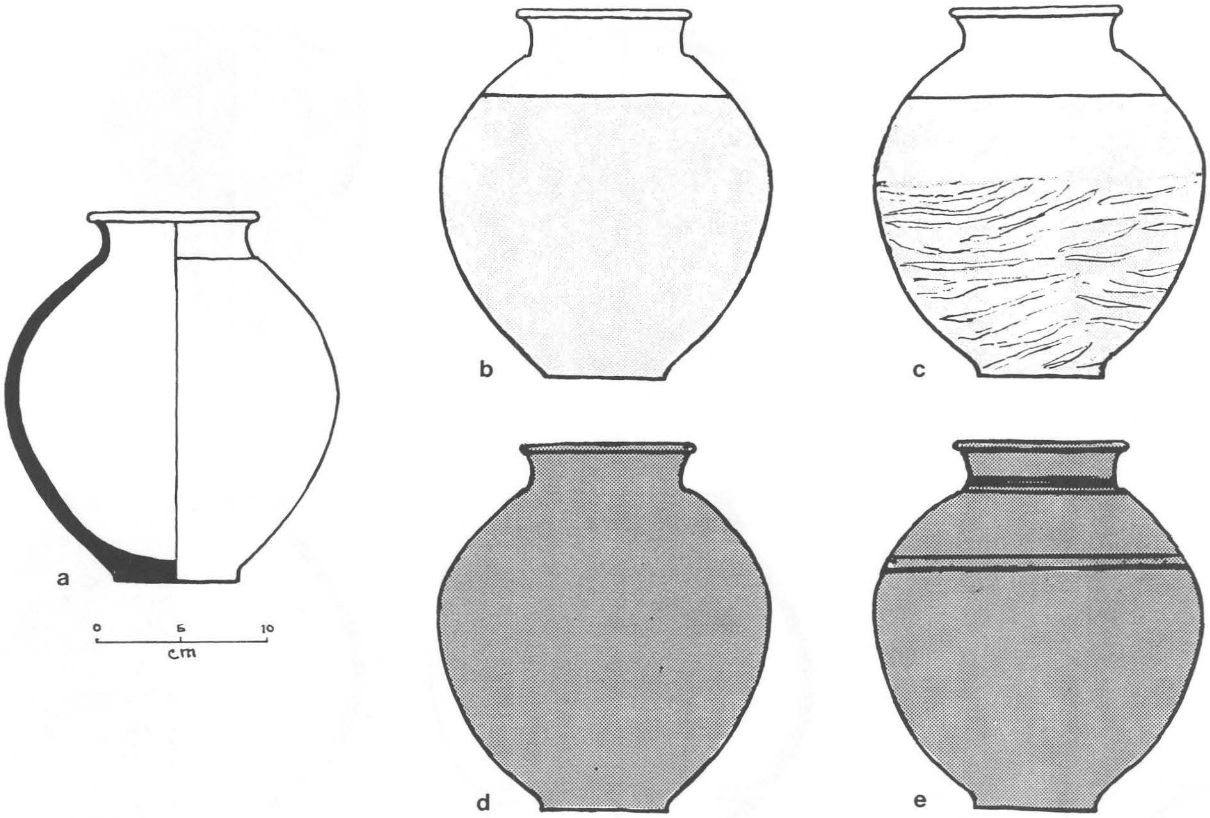

Figure 6.4: Ledge-shouldered jars and the production process.

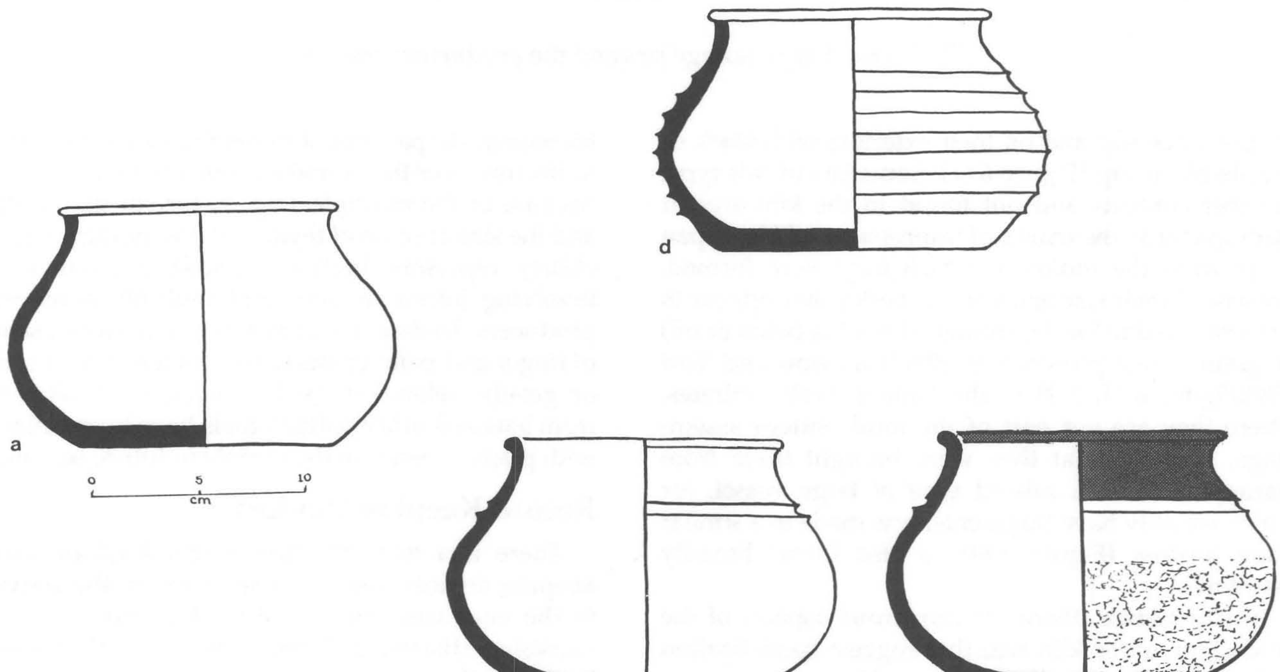

Figure 6.5: Cooking and fluted pots and the production process.

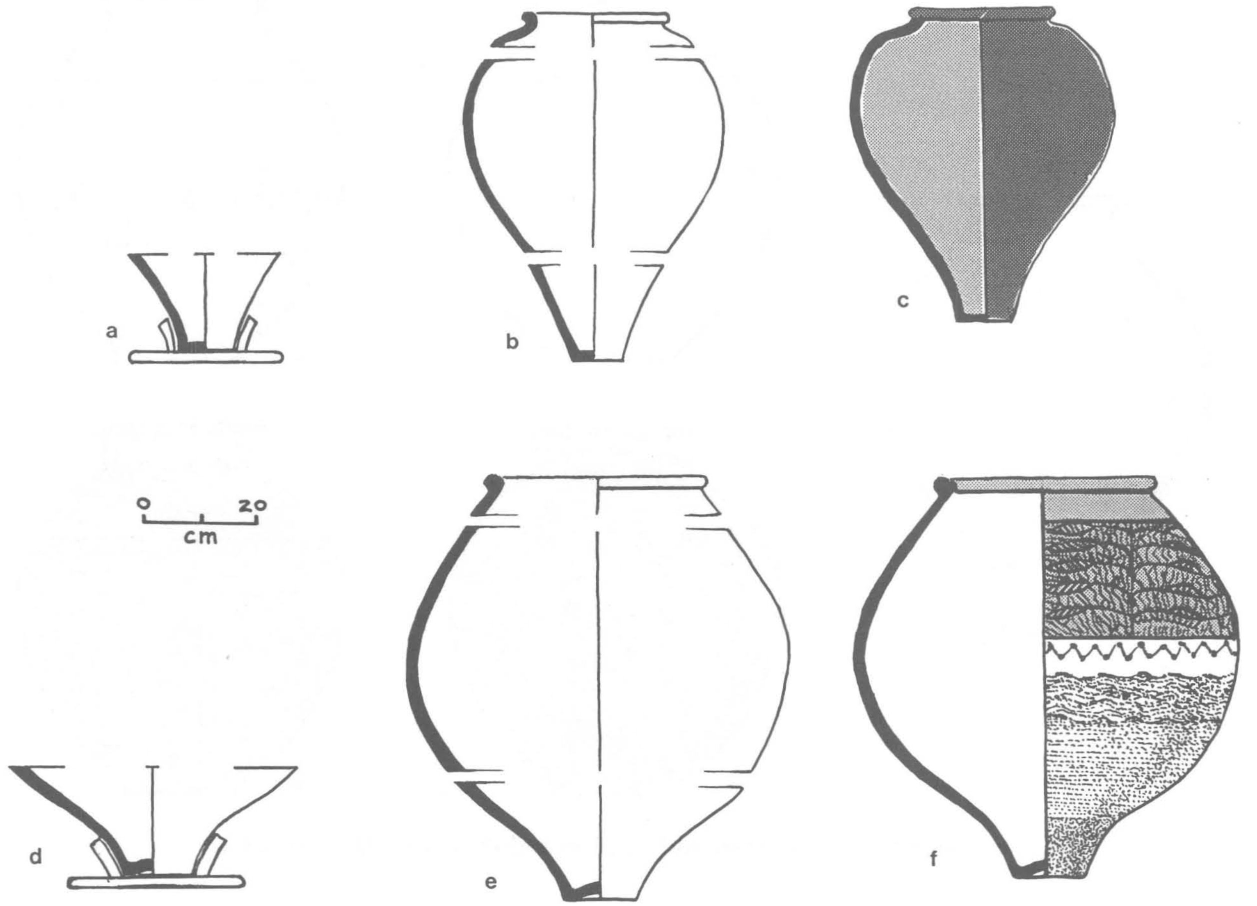

Figure 6.6: Large storage jars and the production process.

purple-black slip and on their exteriors with black or purple-black slip (Figure 6.6c). Some jars of this type, in other contexts and not found in the kiln area at Harappa, bear the marks of impressions of Harappan script from the molds in which they were formed. Because of their size and narrow necks, they appear to be most suitable for the storage of liquids (wine or oil) or grain. Their presence at Hili (Cleuziou and Tosi 1989:Figure 6.11, 1-2) in the United Arab Emirates, where they are not part of the local pottery assemblage, suggests that they were brought there from Harappan sites. A related type of large vessel, for which we only have fragments, was made in a similar stage process (Figure 6.6f), is also found broadly distributed.

To summarize, there are numerous aspects of the production in the kiln area that suggest specialization and standardization. Pottery from this area represents a restricted range of forms produced in uniformly applied production sequences. From a technical point of view, they indicate that the potters had mastered the most complex techniques known at the site. Moreover, the patterns of technology were transmitted uniformly over the period in which the kiln was used. Because of the multiple-stage nature of the products and the size of some of them, e.g., the storage jars, they clearly represent highly specialized manufactures involving intensive labor and multiple numbers of producers. To date, we do not have a sufficient sample of finger and palm prints with which to assess gender or genetic relationships. However, over 200 prints from bats and other potter's tools have been collected, with plans to increase the sample in future seasons.

Record-Keeping Devices

There is a total absence of any kind of record-keeping devices associated with any of the activities in the northwest area of Mound E and the pottery workshop discussed above. This is remarkable since, in many other contexts at Harappa, they are found in large quantities. For example, in previous excavations by Vats (1940) over 971 seals and sealings were discovered in excavations on other mounds. Approximately 70% of the seals were found on

Mound F. Although it is impossible, based on the recording system used by Vats, to determine precisely where individual seals were found, the major installations on Mound F identified by Vats are the "granary," metal working areas, and "workmen's quarters" discussed above.

Conclusion

The evidence discussed in this paper provides some new insights, although, as stated at the beginning, they must be regarded as preliminary, especially since they are based only on macroscopic observations of the pottery and our excavations in this sector are ongoing. In the future, more detailed descriptions and tabulations of the entire corpus of pottery and the production sequences will be completed and published.

This study of pottery from a single production area, in which archaeological evidence and laboratory studies have been combined, provides new evidence for the specialization of production. Specialization can be inferred from the restricted range of types produced in the context of a single activity area and repetition of patterns of technology in the production process. Most of the pottery types present and the technologies employed to produce them show a high degree of efficiency in production and in the multiple sequences employed. Although we have not found stockpiles of raw clay or potters' wheels associated with the kiln, other tools–a chuck, bone spatulae, kiln furniture, pigments, and drying bats–argue for performance of the entire process within the vicinity of the kiln. The large size and fragility of the storage jars also argues for production near the kiln, in which they would eventually be fired. Moreover, these vessels were clearly produced by several potters working together.

The high level of skill of the potters is evident in the final product, in the patterned sequences, and in the tools they employed. The potters at the kiln workshop had developed a range of skills that they recombined, taking a single shape and modifying its form and surface textures through a variety of secondary processes. Moreover, their ability to rework surfaces and join whole sections demonstrate an exceptional working knowledge of clays. The use of several different slip and paint colors shows an advanced understanding of pigments. The potters' wheel, although known in previous periods, was utilized to its maximum efficiency by producing vessels on the hump. The kiln itself represents a complex structure that involved efficiency but also risks in that larger quantities of vessels could be destroyed in a single firing. Although some misfired pottery and kiln wasters have been found, they are not present in large quantities, suggesting a well-developed knowledge of the construction, maintenance, and use of the updraft kiln. The presence of pit kilns in both the previous and same period suggests that different types of kilns were used to produce different wares. Work in the future will be directed toward developing better chronological control and investigating the different wares associated with the different types of kilns. The obvious greater efficiency of the updraft kiln and its ability to accommodate larger vessels makes it ideally suited for the large and technically complex wares that were produced in the kiln area. Kilns of this type also provide greater flexibility with respect to weather and climate, making it possible to fire objects on a year around basis (Arnold 1985:217). For example, contemporary potters in Pakistan who fire their pottery in updraft kilns and who operate under similar weather conditions, produce their pottery throughout the year; most potters in the same region who utilize pit kilns produce on a seasonal basis only (Rye and Evans 1976; tabulated in Arnold 1985:217).

We have not carried out extensive measurements of the hundreds of sherds and small number of whole vessels from the kiln area to assess the degree of standardization. However, they do conform to a restricted range of sizes that is wholly consistent with types found in other contexts at the site. For example, the shape and general morphology of the ledge-shouldered jars (Figure 6.4) found in the recent excavations in the Harappan cemetery (R37) and other published examples from previous excavations is consistent with those produced in the kiln area. Technologically, there also is consistency in the production sequences employed, suggesting sustained and continuous transmission of prescribed patterns of manufacture for these vessels over a substantial period. Although functional studies have not been carried out on any of the pottery at Harappa, the types present in the kiln area are suggestive of food and beverage related use. The care taken in each to achieve an impermeable surface (e.g., thick application of cream slip to the ledge-shouldered jars and red and black slip on the exterior and interior of the large storage jars) are at least as suggestive of the storage of liquids as the shape and textured lower exterior of the pots in Figure 6.5b are of cooking. However, each of these types, if indeed they are food related, were not necessarily produced solely for domestic use, as they are found distributed outside of household contexts. Although very few of the larger jars (Figure 6.6) have been found at Harappa outside of the kiln workshop (Vats did not provide counts, and thus far we have found very few sherds and no whole vessels), the smaller, ledge-shouldered jars and cooking pots have been found in a variety of contexts during the current as well as previous excavations; this indicates their widespread use throughout the city.

The control of production, as indicated earlier, is the most difficult factor to assess, given the lack of deciphered written documentation. When the production studies were originally conceived, I anticipated direct evidence of control in the form of record-keeping devices would be found in production areas. Again, this was based on expectations related to urban processes in general and inferences made by Vats for the finds on Mound F in particular. My expectation was that there would be a classic transition between a kinship type of organization (perhaps represented by the Early Harappan kiln structure associated with a residential structure) and one taken over by the city's authorities.

If we consider the two measures of control, record-keeping devices and the size of the workshop, however, there is no evidence to suggest this transition occurred. The results are, at the least, mixed. The absence of any record-keeping devices or of associated architectural features such as large administrative buildings argues against production controlled by a centralized administrative authority. Production in the kiln area at Harappa is best described as a separate workshop, with relatively high output of standardized manufactures by specialist producers who operated independently. In Brumfiel and Earle's (1987) terms, this is independent production for an unspecified demand group rather than the attached specialists anticipated.

The second measure of control, based on the correlations of size and output developed by Tosi (1984), also does not fit readily with our findings. The workshop described here falls outside of any of his types. While the area is small (his type 2) relative to the size of the site, its *per capita* production was reasonably high (type 4); and, as with his type 3, production was confined to a single craft in which a limited number of products were produced. Our evidence also does not readily conform to recent interpretations of the evidence from Mohenjo-daro. While a relatively small, isolated unit, it is not found in association with other crafts such as the "shop-like arrangements" described for Mohenjo-daro (Pracchia et al. 1985:242), nor does its size warrant the designation of "industrial compound." The third type at Mohenjo-daro, isolated kilns within dwelling areas (Vidale 1989:178), also differs from the Harappa kiln workshop in that it is not directly associated with habitation deposits.

If we view the kiln workshop area in the long-term, we can observe some shifts in associated activities. The earliest kiln in Period 2 is associated with a possible residential structure, indicating a possible change in the organization of production in Period 3, when the area appears to have been given over entirely to the pottery workshop. However, we cannot necessarily assume that production had shifted from household or kinship based production to one more centrally and non-kinship based. Kenoyer (1989), for example, has argued that the use of the same area for pottery production may be more suggestive of a kinship-related craft, where land was occupied over generations by the same kinship group. My study of finger and palm prints is directed specifically to this question.

The principal point, however, is that there is clear evidence that different crafts–if we compare the metal working area at Harappa with the kiln workshop or contrast the pottery workshops at Mohenjo-daro with the ones at Harappa–were absorbed into the urban environment in different ways. Thus there are conditions under which the uniformity and standardization of products do not, in and of themselves, reflect control by a bureaucratic system. Differential control of crafts may be related to the function of different products, or, as Carla Sinopoli (1989:271) has proposed for medieval Vijayanagara, their utility to local administrators. In the kiln workshop, it is reasonable to assume that some of the pottery types there, such as cooking pots and ledge-shouldered jars may not have been of interest to administrators. On the other hand, the large storage jars (Figure 6.6), with their linkage to broad-ranging distribution systems, clearly would have been.

Additional factors are the long-term historical processes involved in the organization of pottery production and the implementation of power. The craft of pottery manufacture began during the Sixth millennium BC in the Indus region (Jarrige and Lechevallier 1979), and almost from its inception, pottery objects appear to have been highly valued, to judge from the large number of fine wares produced, the standardization of morphology and design, and the extensive exchange networks that developed (Wright 1985). The context of production during these early (pre- and Early Harappan) periods was within independent household units. Over a long period, the efficient organization of production based on kinship may have constrained its takeover by a more hierarchically-ordered system. As I have suggested elsewhere (Wright 1983), we should at least consider the possibility that family and kinship units that controlled production resisted their takeover and successfully maintained a non-centralized social structure (Wright 1987:75). Viewed in the long-term, the continued control of production by some segments of the society in the Harappan urban environment simply follows a well-established historical pattern that developed early and was sustained throughout the history of the region.

Finally, if these findings are supported by future research, they challenge our assumptions about the organization of production in early states and urbanism. The Harappan evidence does not indicate a tightly controlled administrative network, but rather one with flexibility in which different types of production organized in different ways were absorbed into the urban system. It also suggests that kinship groups in the Harappan civilization continued to exist as viable political and economic entities, a factor that wholly conforms to the Mesopotamian evidence and to that from other urban contexts. Adams (1966), for example, has referred to documentation in the Early Dynastic period that attests to lineages or clans composed of craftsmen or agriculturalists who apparently were not controlled by the state. Yoffee (1979) has documented the similar viability of kinship in the later Old Babylonian period. The point to be made is that states probablly did not monopolize or control the organization of production, nor did their power go uncontested. What seems most likely is that in these early attempts to monopolize and establish uncontested power, the same "disgruntlement, foot-dragging, escapism, sabotage, protest or outright resistance" (Wolf 1990:590) exhibited by interest groups with their own agendas of power would have emerged as viable entities in the past, just as they do today.

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Cover art: Bowl on Stand H88-1002/192-17 associated with Burial 194a
in Harappan Phase Cemetery (see Figure 13.18).

7

Faunal Remains and Urbanism at Harappa

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Excavations at the third millennium BC urban site of Harappa (Punjab, Pakistan) have produced a large quantity of mammal bone remains. Two features of this material—bone measurements and density of bone in excavation units—are considered from the point of view of using aspects of assemblage variability to document faunal exploitation and site formation processes. Measurements of cattle, sheep, and goat bones from Area C on the south side of Mound E are compared with those documented from earlier levels at the site of Mehrgarh and contemporary levels at Nausharo (Baluchistan, Pakistan). The results suggest that different breeds of sheep and cattle may have been kept in the two regions during the Harappan phase. The density of bone deposited in Street NS2355, when considered in combination with the nature of the street deposits and adjoining architecture, permits one to monitor the cycle of urban life in that part of Harappa. It appears that only during Period 2 (or early Period 3A) and late in Period 3B was the street actively maintained or reconstructed. At other times it served as an open sewer, acted as a dump for debris from nearby households, or fell out of active use as a thoroughfare.

During the Indus Valley Tradition fluctuating tensions created by pressures for both uniformity and diversity drove the cultures of the region into and out of phases of integration and regionalization, urbanization and deurbanization (Shaffer 1991). The underlying forces and resulting patterns are usually most clearly manifest in aspects of technology, sociopolitical organization, and ideology as these are reflected in the material culture. Nevertheless, some of the most profound changes during the second half of the third millennium in the Greater Indus Valley took place in subsistence practices (Costantini 1981; Jarrige 1985; Meadow 1989a; Weber 1990, 1992).

A common feature of the Harappan phase (ca. 2600–2000 BC) in the Indus valley alluvial zone appears to have been an agricultural foundation of winter crops—including principally barley and wheat—and domesticated bovids—including cattle, sheep, and goats (Costantini 1981, 1984, 1990; Meadow 1987, 1989a). Yet the details of subsistence practice as revealed by the plant and animal remains at individual sites vary considerably depending upon resource availability as dictated by geographical and cultural factors. While topography, soils, climate, water, and natural vegetation provided possibilities for or placed physical constraints on plant and animal husbandry, it was the knowledge of individual farmers and herders that dictated how such resources were used.

In a like manner, birds, fish, and terrestrial game might have been available to a population but not used to any great extent. A specific example is provided by the coastal site of Balakot. In the late fourth and early third millennium Balakotian levels, fish bones and mollusc shells are rare. Clearly the population had access to and perhaps some knowledge of coastal habitats, but did not exploit them as a major source of food. In contrast, during the Harappan phase at the same site, both fish and mollusc remains are plentiful suggesting that those faunas were heavily harvested (Dales 1979, 1986; Meadow 1979; Belcher, Chapter 8 in this volume).[1]

Defining variability in subsistence activities between sites and even between phases at the same site is not a straightforward task (Meadow 1978a,

1989b). Techniques of food preparation, disposal practices, and depositional events influence the character of the floral and faunal records (flora: e.g., Dennell 1976; Hillman 1984; fauna: e.g., Gilbert 1979; Meadow 1980). In addition, the indiosyncrasies of specific events as well as day-to-day, season-to-season, and year-to-year variability are reflected in the plant and animal remains (Wright, Miller, and Redding 1980). Some might argue that our understanding of past plant and animal exploitation practices is directly related to our ability to identify and control for such biasing factors. Another approach is to actively examine the variability in the archaeological record and frame questions to identify both general trends and specific variations that can provide insight into the constraints lying behind individual activities. In this way, floral and faunal remains can provide information both on subsistence practices and on phenomena beyond the strictly subsistence sphere.

With respect to faunal remains, I provide two examples here. The first uses the dimensions of sheep, goat, and cattle bones from the neolithic and chalcolithic levels at Mehrgarh (District Kachi, Baluchistan, Pakistan), from the Harappan periods at the nearby site of Nausharo, and from the Harappan phase at Harappa (District Sahiwal, Punjab, Pakistan) to investigate differences in animal husbandry practices through time and between different regions of what is now Pakistan. The second example employs data on the abundance of bones in street deposits at Harappa to monitor the cycle of urban life.

Materials and Methods

The site of Mehrgarh is located in the northern part of the Kachi Plain at the foot of the Bolan Pass in eastern Baluchistan. Excavated between 1974 and 1985, it has a more or less continuous series of deposits that run from the 6000+ BC "aceramic neolithic" (Mehrgarh Period IA) through the "coarse ware neolithic" (MR.IB-IIA) and "fine ware neolithic" (MR.IIB) into the "chalcolithic" (MR.III, IV, V, and VI) and "early bronze age" (MR.VIIA-C) (Jarrige and Lechevallier 1979; Jarrige 1981, 1985; Lechevallier and Quivron 1981, 1985).

Deposits at the nearby site of Nausharo overlap in time those of Mehrgarh Period VII and continue through the Harappan phase. Thus Mehrgarh Periods VIIA-C are approximately contemporary with Nausharo Periods IA-C. Nausharo Period ID (ca. 2500 BC) follows and is overlain by the Harappan phase Periods NS.II and NS.III (Jarrige 1986, 1988, 1989), which in turn are approximately contemporary with Periods 3A and 3B at Harappa (Chapters 4 and 13 in this volume). While the faunal material from Mehrgarh discussed here has previously been published (Meadow 1981, 1984a, 1984b, 1989b, and specifically Meadow 1992), information on the fauna from Nausharo is presented for the first time. It comprises bones and teeth from Harappan phase deposits of Periods II and III on the southern mound that were excavated during the 1986 and 1987 seasons.[3]

The site of Harappa is located near near the town of Sahiwal south of the river Ravi about halfway between Lahore and Multan. The mammal bones considered here were excavated during the 1990 season and come from street and trash deposits excavated in Area C on the southern slope of Mound E that can be assigned principally to Periods 3A and 3B (see Chapters 4 and 13 in this volume, Figure 7.7, and the discussion below). The 5,554 specimens that form the basis of Figure 7.8 come from the street deposits alone and were identified at least to size of animal. These deposits were dry-sieved through wire screens (ca. 1/4 inch or 64 mm mesh). All materials from the street levels were analyzed with the exception of some of the bones from Lot 3151 that remain to be studied.[4]

Identifications for the Mehrgarh, Nausharo, and Harappa materials were made on the basis of accumulated experience of the analysts, notes compiled over the years on osteological differences, and modern comparative collections some of which were made at Mehrgarh and Harappa and are stored at those sites. Data was computer coded following the protocol defined in Meadow (1978b) and manipulated on Macintosh® computers using Microsoft® Excel©. Bone weights were taken to the nearest half-gram on a metric postal scale. Measurements were made with dial or digital calipers to the nearest 0.1 mm with an estimated accuracy of ±1%. Measurement definitions generally follow those of von den Driesch (1976) with the exception of the ones for carpals that are defined by Stampfli (1963).

Bone measurements are taken to document the size and build of the animals exploited (Boessneck and von den Driesch 1978). Size in animals has two components: weight and height. Breadth and depth measurements of appendicular bones reflect the weight supported by each limb of the animal, while lengths especially of the long bones and phalanges are correlated with the height of the animal (von den Driesch and Boessneck 1974). Some zooarchaeological studies of animal size change and variability have not dealt with these two types of dimensions separately, primarily because of the small numbers of the measurable bones in any given assemblage. For this study, however, lengths were graphed separately from breadths and depths (Figures 7.1–7.6 as well as Meadow 1992).

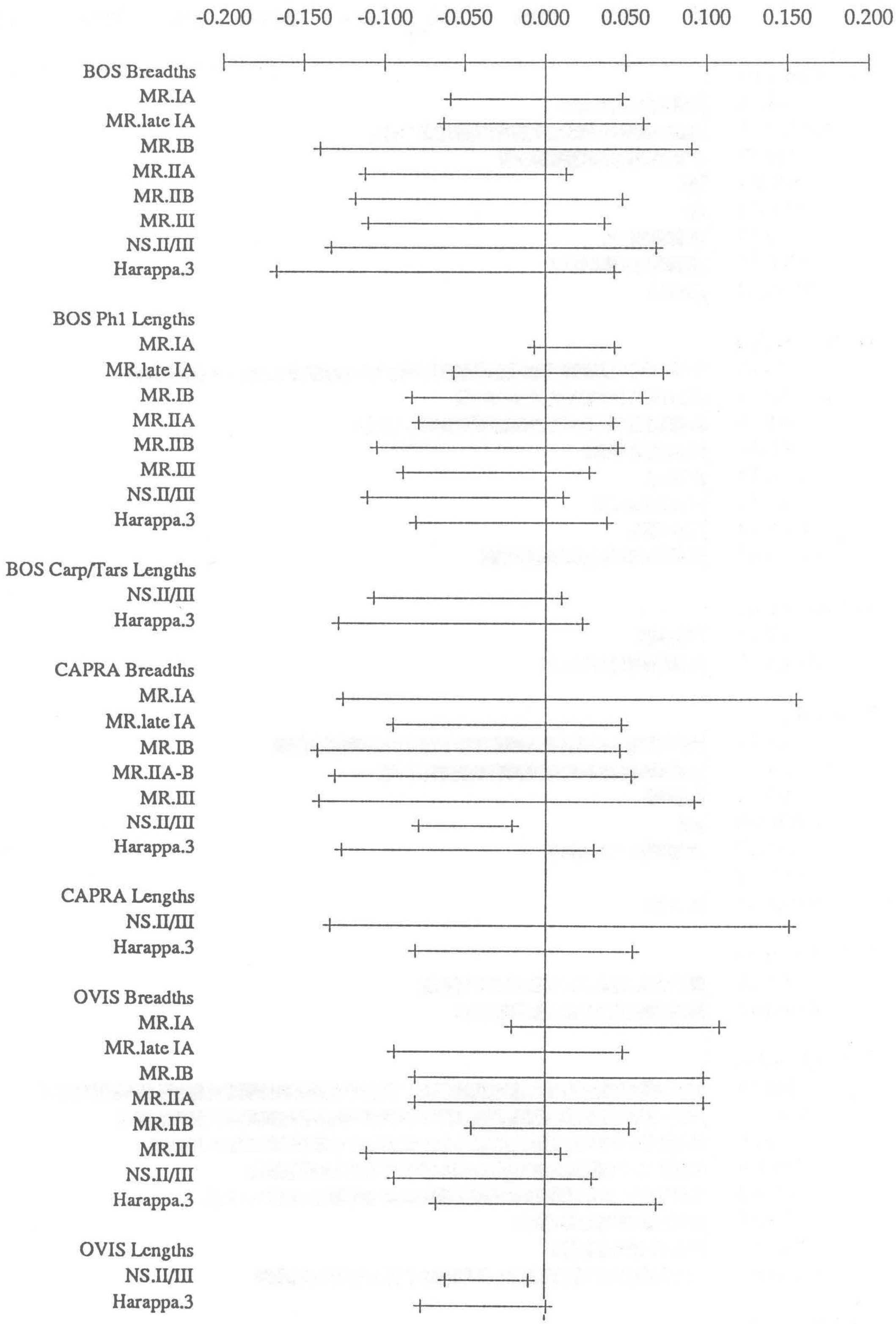

Figure 7.1: Difference of Logarithms diagram showing ranges of dimensions for bone lengths and breadths from Mehrgarh (MR), Nausharo (NS), and Harappa. Assemblages are arrayed from earliest (at top) to latest, but with Nausharo Periods II/III and Harappa Period 3 being approximately contemporary. The standard dimensions (represented as 0.000) with which the archaeological specimens were compared are listed in Table 7.1. Values for the plotted data along with sample sizes are listed in Table 7.2.

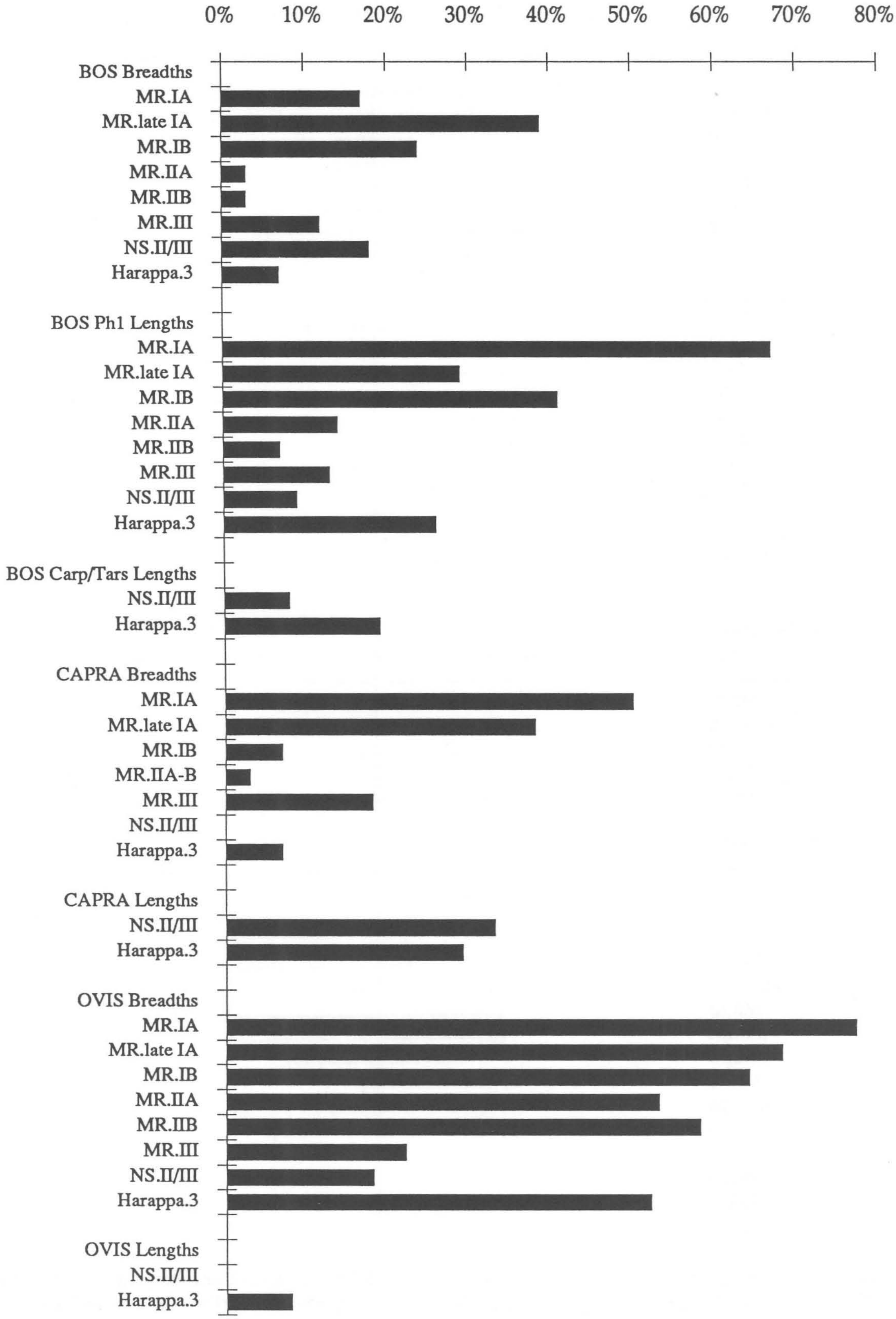

Figure 7.2: Diagram showing the percentage of measured specimens that are larger than the standard. See caption to Figure 7.1 for further details.

The procedure employed to document animal size where relatively few bones are measurable was first described by Meadow (1981). Called the "difference of logarithms" or "log difference" technique, it permits the plotting of dimensions of different skeletal parts on the same set of axes. Thus in Figures 7.3–7.6, the "0-lines" represent selected dimensions of "standard animals" (see Table 7.1 for these values) which, together with the corresponding measurements from the archaeological specimens, are converted into logarithms and subtracted the first from the second. Each vertical line in these figures represents a single dimension, with log difference values that are larger than the standard plotted above the "0"-line and values that are smaller plotted below.

Use of the log difference technique is limited to revealing trends in the data. Because one must assume that skeletal part allometry in each archaeological animal is the same as in the standard animal to which it is compared, one cannot use the technique to identify the sex or other characteristics of individual specimens, something which can be done only on a skeletal part by skeletal part basis.

Animal Husbandry

For the Middle East and Europe, documentation of skeletal part dimensions has shown that there was a decrease in the overall size (height and weight) of sheep, goats, cattle, and pigs over the course of their first domestication (e.g., Boessneck et al. 1971; Clason 1979; Davis 1987; Grigson 1989; Helmer 1989; Uerpmann 1978, 1979). By the mid-third millennium BC, however, one can expect to see the development of special breeds of animals and special husbandry practices that should be reflected in the zooarchaeological record (see Boessneck et al. 1971; Crabtree 1990; Davis 1984, 1987; Zeder 1984, 1988, 1991). These developments would have resulted through conscious and unconscious selection stimulated by the widespread use of domestic animals in different environmental settings, the growth of urban centers requiring provisioning, an increasing focus on secondary products such as milk, wool, and traction, and the possible formation of specialist pastoral groups.

In Mesopotamia, the use of sheep, goats, and cattle for dairy products and the presence of wool-bearing and fat-tailed sheep are documented in the texts or iconography from the site of Uruk by the end of the fourth millennium BC (Green 1980; Zeuner 1963:173). At the same time, symbols in the form of plows occur on proto-elamite and archaic tablets (Damerow and Englund 1989:71, MDP31:4463; Sherratt 1981:Figure 10.4), and what appears to be a symbol in the form of a cart is incised on archaic tablets from Uruk (reproduced in Littauer and Crouwel 1979:Figure 1). Presumably, both plows and carts were drawn by cattle in the fourth millennium as they were in later periods (Littauer and Crouwel 1979; Sherratt 1981).

Table 7.1: Standard Dimensions used to compile Figures 7.1 through 7.6 and Table 7.2.

Dimension	*Bos* (zebu)	*Ovis* (sheep)	*Capra* (goat)
Scapula (BG)	58.7	22.0	24.7
Humerus (BT)	89.5	29.5	34.2
Radius (Bp)		33.5	35.5
Radius (BFp)	87.1		
Radius (Bd)	84.3	31.0	33.2
Ulna (BPC)	56.3	19.0	
Ulna (DPA)			29.5
Radial Carpal (L)	34.0		
Intermediate Carpal (L)	31.4		
Ulnar Carpal (L)	36.7		
Carpal II+III (GB)	38.6		
Carpal IV (B)	34.1		
Metacarpal (Bp)	65.7	25.0	27.3
Metacarpal (Bd)	68.9	26.5	30.5
Pelvis (LA)	80.5		
Femur (DC)	54.9	21.0	23.0
Tibia (Bd)	71.6	26.5	
Tibia (Dd)			21.7
Lateral malleolus (GD)	40.3		
Astragalus (GLl)	75.4		
Astragalus (Bd)	51.4	19.6	20.8
Central+IV Tarsal (GB)	66.7		
Tarsal II+III (D)	40.6		
Metatarsal (Bp)	54.4	22.5	23.0
Metatarsal (Bd)	64.3	26.0	28.5
Phalanx I ant. (GLpe)	68.7		
Phalanx II ant. (GL)	44.0		
Phalanx I post. (GLpe)	69.0		
Phalanx II post. (GL)	45.2		
Phalanx I mean (GLpe)	68.9		

All dimensions in mm. L = Length, B = Breadth, D = Depth. For measurement definitions, see von den Driesch (1976) and Stampfli (1963). *Bos indicus* (Museum of Comparative Zoology 51755) adult male, collected by S.J. Olsen, Ft. Meade, FL, USA, 1957, measured by R.H. Meadow (Meadow 1986); *Ovis orientalis* (Field Museum of Natural History 57-951), adult female from western Iran; *Capra aegagrus* (British Museum [Natural History] 653M and 653L2) average of adult male and adult female from the Taurus mountains; sheep and goats measured by H.-P. Uerpmann (Uerpmann 1979, Table A-3).

Unfortunately little use has been made of faunal remains from Mesopotamia to identify changes in animal exploitation patterns or morphologies that could have accompanied the development of the new husbandry practices and breeds. That such an

approach may be promising is demonstrated by a study of the measurements of sheep remains from the Early Dynastic III and Old Babylonian periods (Meadow, in preparation). Log difference diagrams show that there was an overall increase in animal size toward the end of the third millennium, a phenomenon that might have resulted from the introduction of new breeds to the region.

Moving east to the Greater Indus Valley, decreases in the size of cattle, goat, and sheep also appear to have taken place starting in the 6th or even 7th millennium BC (Meadow 1984b, 1992). Details of that phenomenon, which I have argued elsewhere was a local process at least for sheep and cattle (Meadow 1984b, 1992), can be reviewed in Figures 7.1 and 7.2 and in Table 7.2. In Figure 7.1, maximum and minimum log differences for cattle, goat, and sheep bones are plotted for different assemblages of the neolithic, early chalcolithic, and Harappan periods. In Figure 7.2, the percentage of specimens that are larger than the standard is shown for each of the same divisions. Length and breadth dimensions are treated separately, and some sample sizes are quite small as can be seen by examining Table 7.2.

For cattle (*Bos* sp.), bone breadths—reflecting animal weight—decrease during the ceramic neolithic (between MR.IB and IIA—Figure 7.1), and the percentage of large specimens also decreases (Figure 7.2). There is, however, considerable variability in MR.IB, suggesting a period of change in cattle exploitation practices. Great variability is also present during the Harappan phase (Figures 7.1–7.4). At Nausharo, very heavy as well as light animals are represented, and there is an increased percentage of bones from heavier individuals. In contrast at Harappa, the percentage of heavy animals remains low and extremely small breadth dimensions have been recorded.

The picture is rather different when a single length dimension such as that of the first phalanx is considered. Size (height) decrease is almost continuous from the aceramic neolithic at Mehrgarh into the Harappa phase at Nausharo (Figure 7.1), although the greatest change in percentage of large specimens still occurs in the ceramic neolithic between MR.IB and IIA (Figure 7.2). Of potential significance is the fact that the lengths and percentages of long specimens for both first phalanges and carpals/tarsals are considerably greater at Harappa than at Nausharo.

To judge from these data, the cattle of Harappa were lighter but taller than those at Nausharo during the Harappan phase, suggesting the presence of different breeds (just as there are today). As additional specimens are documented, this hypothesis needs to be tested on a skeletal part by skeletal part basis.

Table 7.2: Statistics Used to Compile Figures 7.1 and 7.2

	No.	Min. log dif.	Max. log dif.	%>0
Bos Breadths				
MR.IA	18	-0.059	0.048	17%
MR.late IA	18	-0.063	0.061	39%
MR.IB	55	-0.140	0.091	24%
MR.IIA	64	-0.112	0.013	3%
MR.IIB	68	-0.118	0.048	3%
MR.III	42	-0.110	0.037	12%
NS.II/III	38	-0.133	0.069	18%
Harappa.3	84	-0.167	0.043	7%
Bos Phalanx 1 Lengths				
MR.IA	6	-0.007	0.043	67%
MR.late IA	14	-0.057	0.073	29%
MR.IB	29	-0.083	0.060	41%
MR.IIA	29	-0.079	0.042	14%
MR.IIB	30	-0.105	0.045	7%
MR.III	16	-0.089	0.027	13%
NS.II/III	23	-0.111	0.011	9%
Harappa.3	34	-0.081	0.038	26%
Bos Carpal/Tarsal Lengths				
NS.II/III	12	-0.107	0.010	8%
Harappa.3	21	-0.129	0.023	19%
Capra Breadths				
MR.IA	52	-0.126	0.155	50%
MR.late IA	8	-0.095	0.047	38%
MR.IB	28	-0.142	0.046	7%
MR.IIA-B	33	-0.131	0.053	3%
MR.III	28	-0.141	0.092	18%
NS.II/III	7	-0.079	-0.021	0%
Harappa.3	14	-0.127	0.030	7%
Capra Lengths				
NS.II/III	9	-0.134	0.151	33%
Harappa.3	7	-0.081	0.054	29%
Ovis Breadths				
MR.IA	56	-0.021	0.108	77%
MR.late IA	22	-0.094	0.048	68%
MR.IB	75	-0.081	0.098	64%
MR.IIA	32	-0.081	0.098	53%
MR.IIB	19	-0.046	0.052	58%
MR.III	18	-0.111	0.010	22%
NS.II/III	28	-0.094	0.029	18%
Harappa.3	63	-0.068	0.069	52%
Ovis Lengths				
NS.II/III	7	-0.062	-0.010	0%
Harappa.3	12	-0.077	0.001	8%

MR=Mehrgarh (see Meadow, 1992);
NS=Nausharo; No.=number of specimens;
Min.log dif.=minimum log difference;
Max.log dif.=maximum log difference;
%>0=percentage of log differences greater than 0.000.

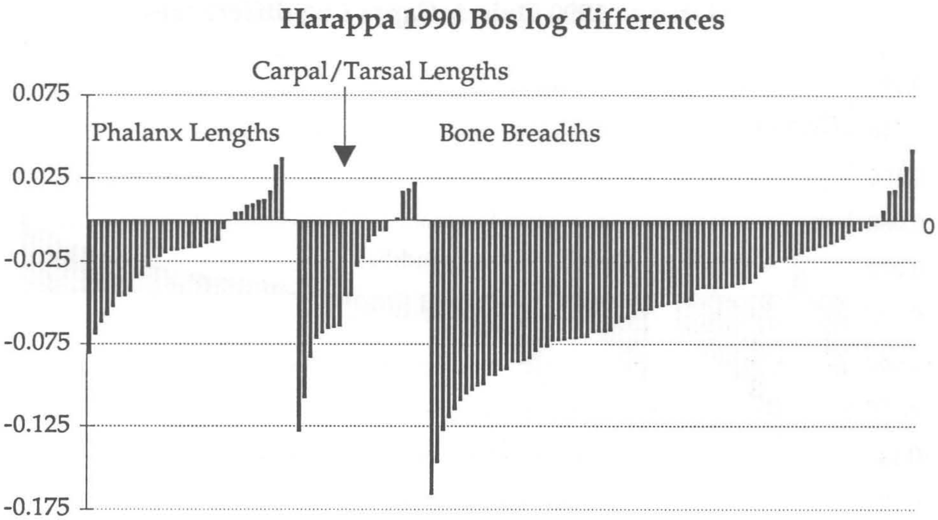

Figure 7.3: Difference of Logarithms diagram for cattle (*Bos*) bones from Harappa showing distribution of individual measurements in relation to the standard.

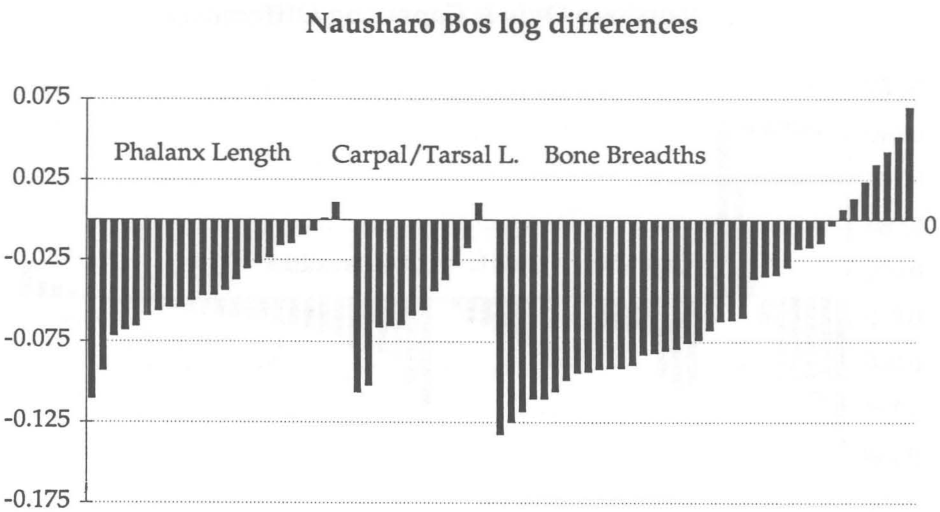

Figure 7.4: Difference of Logarithms diagram for cattle (*Bos*) bones from Nausharo showing distribution of individual measurements in relation to the standard.

Furthermore, whether these patterns developed only in the Harappan phase or had earlier roots is a question that remains to be answered.

For goats (*Capra* sp.), the picture is somewhat different than for cattle. In the earliest levels at Mehrgarh, small, light-weight, presumably domestic animals and heavy, presumably wild individuals are both represented (Figure 7.1), although a relatively high proportion of the specimens come from animals larger than the standard (Figure 7.2). By ceramic neolithic MR.IB, size decrease in goats appears to have ended, with relatively few heavy animals represented in any of the later periods. Unfortunately, bone lengths could be plotted only for the Harappan phase and then only for very few specimens (Table 7.2, and Figures 7.5–7.6). There is enormous variability represented at Nausharo and a considerable proportion of tall animals at both Nausharo and Harappa. Taken at face value, it appears that both long-legged animals and small, even dwarf, individuals are represented, although once again it is necessary to document a larger sample of material and to examine the bone

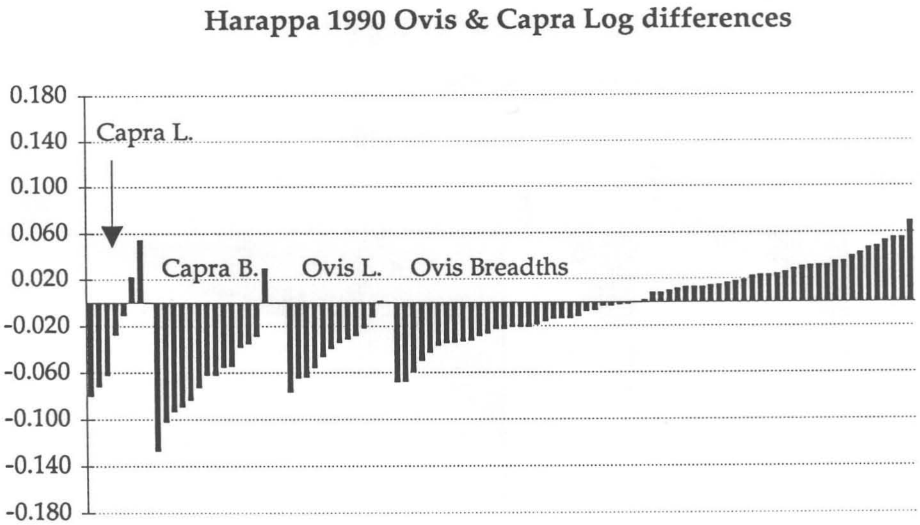

Figure 7.5: Difference of Logarithms diagram for goats (*Capra*) and sheep (*Ovis*) bones from Harappa showing distribution of individual measurements in relation to the standard.

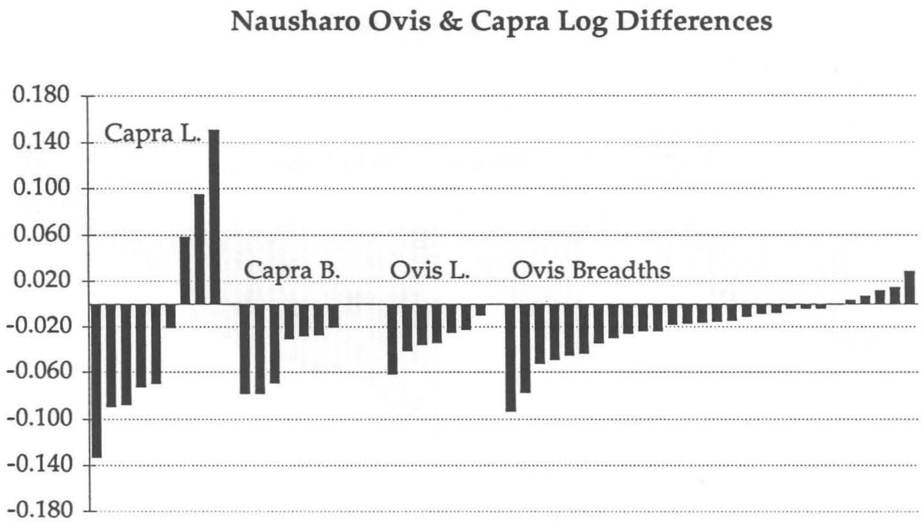

Figure 7.6: Difference of Logarithms diagram for goats (*Capra*) and sheep (*Ovis*) bones from Nausharo showing distribution of individual measurements in relation to the standard.

dimensions element by element. The possibility of wild goats being represented at Nausharo during the Harappan phase also must not be overlooked.

For sheep (*Ovis* sp.), the patterns are again different than for cattle and goats. Although relatively small (light) animals are represented in the late levels of the aceramic neolithic (MR.late IA), size diminution is not really complete until early chalcolithic MR.III. By that time, not only are the bones considerably smaller (Figure 7.1), but there are many fewer large specimens (Figure 7.2). Indeed in assemblages earlier than MR.III, more than 50 percent of all sheep bones measured are broader than the standard. Thus at Mehrgarh one can define two episodes of size diminution in sheep—one within aceramic neolithic MR.IA coinciding with sheep remains becoming much more frequent than those of goats and one between late neolithic MR.IIB and chalcolithic MR.III when goats become better represented than sheep (Meadow 1992).

During the Harappan phase at Nausharo, bone breadths and the proportion of large animals are about the same as for chalcolithic Mehrgarh. This contrasts

with the situation at Harappa, where more heavier (but not much taller) animals are represented for the same time period (Figures 7.1, 7.2, 7.5, 7.6). In addition, whereas sheep are better represented than goats at both sites, the ratio of sheep to goats at Harappa is 3.7 to 1 (n=220) as compared with 1.5 to 1 (n=207) at Nausharo. Thus it appears that sheep are markedly larger bodied and relatively more abundant at Harappa than at Nausharo. As with cattle, this may represent different breeds and different husbandry practices. Study of sheep demographics (kill-off patterns and sex ratios) will permit comparison of animal exploitation at the two sites and and may aid in identification of the effects of local environmental differences and socio-cultural choices.

The Cycle of Urban Life at Harappa

Beyond simply providing information on husbandry practices, faunal remains can be used to help monitor the cycle of urban life. Middle Eastern or South Asian towns often contain run-down areas that are temporarily used for dumping garbage and other debris. And even when an area is being actively occupied, streets are used for the disposal of trash including animal bones. Those streets of concern to the civic authorities may eventually be cleaned, while those streets that are ignored will literally fill up with debris between the walls of the structures on either side. Such build-up can occur even to the extent that new doorways have to be cut into existing buildings to provide access to dwelling units the ground floors of which are up to two meters below the street level.

Examples of such differences in elevation of contemporary living surfaces can be found in modern Harappa town today and provide a valuable model for interpreting the archaeological record. In particular, contemporary deposits inside of and outside of buildings need not be at the same absolute elevations, and it is often impossible to demonstrate stratigraphically the precise relationships between such deposits. We are thus compelled to draw together different lines of evidence—including plans of structures, locations of doorways, elevations of drains, and the nature of artifactual and ecofactual debris—to inform ourselves about the form of the settlement at any given time and how it changed over the decades.

Turning specifically to the south side of Mound E at Harappa, based on what is known to date of the architectural and artifactual remains, Kenoyer (this volume, Chapter 4) proposes that expansion into this part of the site took place during Period 2. This first settlement, debris from which is almost 1.5 m thick in places, was followed by a substantial initial Period 3A Harappan phase occupation, including habitation structures and a major town wall. Kenoyer proposes that, subsequently, this part of the city was ignored by the civic authorities, with the town wall and buildings falling into disrepair. With Period 3B, attention was once again focused on this quarter with new structures being built and the town wall repaired.

Portions of the north-south Street NS2355 were excavated on the south side of Mound E during the 1990 season. In Area C, this street was found to have been established during Period 2 (Early Harappan/ Harappan transitional phase) and to have continued through at least Period 3C (Chapters 4 and 13 in this volume). Possible ruts made by cart wheels were identified at two levels—in natural sediment (Period 2: Lot 3176 below lot 3172; Figures 4.12 and 13.41) and in street fill outside the walls of an Harappan phase house structure (Period 3B: Lot 3052 below lot 3048; Figures 4.16, 8.2, and 13.40). Between the "cart tracks on natural soil" and the "upper street levels" were multiple layers of fill deposited on well-defined street surfaces (Figure 7.7, right side) that range from a maintained horizontal surface to pitted, green-stained, garbage-filled muck.

The excavation units ("Lots") defined for Street NS2355 are listed in Table 7.3 along with the absolute elevations for the *top* of each lot (to assist the reader in finding their location in Figure 7.7). Also presented are comparisons of the approximate volume of sediment removed for each lot, the number of mammal bones in each lot and their total weight, measures of the density of bone (number of bones per cubic meter), and measures of bone size (average weight per specimen). These last two statistics are graphed on a base 10 log scale in Figure 7.8.

As far as the dating of the different levels are concerned, Early Harappan phase sherds occurred in the cart tracks in the lowest level and in the lowest 30 cm of street debris (Lots 3176 and 3172). A bit higher, a fragment of an engraved Indus seal (Figure 13.44e) turned up at the base of Lot 3166, nearly at the bottom of the street deposits (elevation of ca. 162.31m). The immediately preceding strata of Lot 3171 as well as those of 3166 and of all succeeding lots yielded Harappan phase pottery. Seven meters to the east, Early Harappan potsherds in association with hearths came from deposits nearly 1.5 m higher (from an elevation of 163.78m). Thus at the end of Period 2 some of the habitation levels were considerably higher than the street. Although no specific evidence of street fill removal was detected in the excavations, it is possible that some of the Period 2 street levels were eroded or removed during the course of Period 3A use.

During Period 3, over two meters of deposit accumulated in the street and can be related to three major

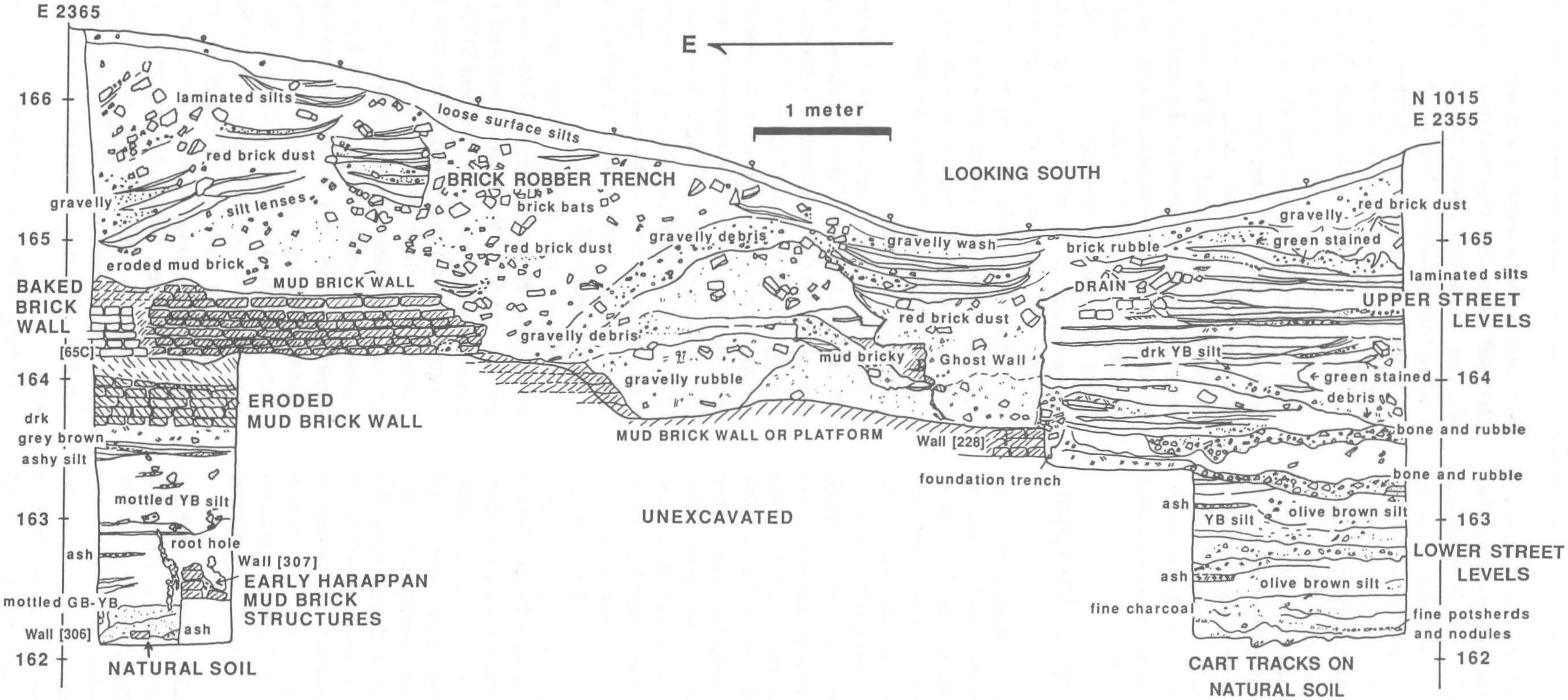

Figure 7.7: Harappa 1990: Section facing South of trench in Area C on the southern side of Mound E. Street NS2355 deposits are on the right (west) side of the section. Elevations are in meters.

Table 7.3: Harappa Mound E South, Area C, Street NS2355

Lot	meters	AMSL	m^3	#	wt	$\#/m^3$	wt/#
3048	164.65	164.70	0.79	19	233.0	24.1	12.3
3052	164.63	164.52	0.45	0	0	0	
3055	164.43	164.51	1.11	168	1605.0	151.4	9.6
3056	164.32	164.31	4.53	551	5588.5	121.3	10.1
3062	164.01	163.93	2.23	326	2102.5	146.2	6.4
3065	163.78	163.69	0.65	122	1841.0	187.7	15.1
3066	163.66	163.57	1.07	204	1135.0	190.7	5.6
3151	163.43	163.42	1.63	1125	15564.0	690.2	13.8
3153	163.19	163.23	2.23	400	5439.0	179.4	13.6
3156*	163.30	163.40	1.01	186	2079.5	184.2	11.2
3161	163.00	162.76	0.38	150	1018.0	394.7	6.8
3162*	163.00	162.82	2.08	115	1010.0	55.3	8.8
3164	162.67	162.65	0.67	105	664.0	156.7	6.3
3165	162.60	162.55	0.24	91	635.0	379.2	7.0
3166*	162.62	162.60	2.10	454	2576.0	216.2	5.7
3171	162.35	162.31	0.74	1495	4743.5	2020.3	3.2
3172	162.26	162.19	1.04	43	86.5	41.3	2.0
3176	162.07	Natural Sediment					

*=Lot overlaps and is approximately contemporary with the one listed immediately above;
Lot 3151 has not been completely analyzed;
meters AMSL=greatest and least absolute elevations in meters of **top** of Lot;
m^3=approximate volume in cubic meters of sediment associated with the Lot;
#=number of specimens in the Lot;
wt=total weight in grams of specimens in the Lot;
$\#/m^3$=number of bones per cubic meter in the Lot;
wt/#=average weight of specimens in the Lot.

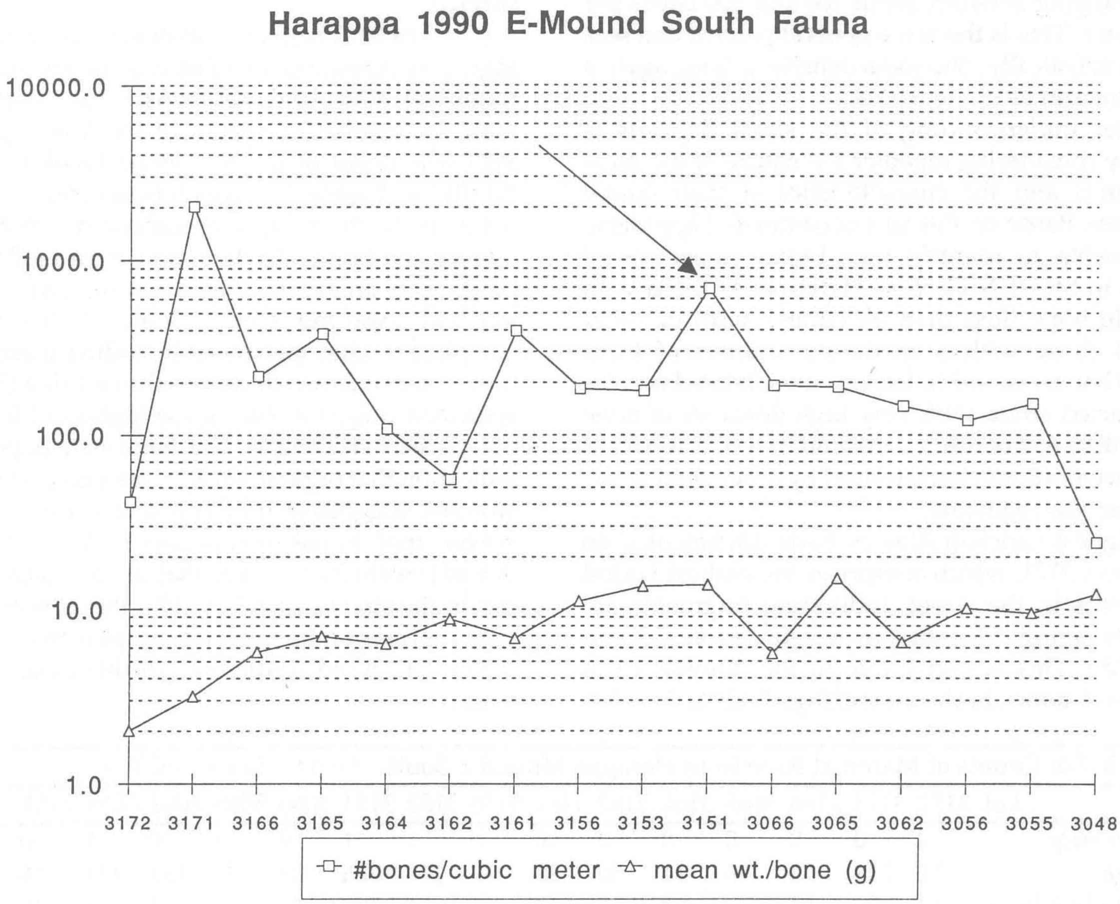

Figure 7.8: Log (base 10) plot of number of mammal bones per cubic meter and mean weight in grams of bone from Street NS2355 excavation units (Lots) arrayed from earliest (left) to latest (right). Values for the plotted data are listed in Table 7.3. The arrow points to the symbol for Lot 3151 to remind the reader that additional bones from that excavation unit remain to be analyzed.

episodes of building. The earliest episode is assigned to the beginning of Period 3A and the later ones to Period 3B. The Period 3A building was made of mud-bricks which came to be heavily eroded after abandonment, probably indicating the passage of a significant period of time. Before the second mud-brick building came to be built, the first had been filled and covered with debris including large articulated carcass portions of cattle (Lot 3255). The second mud-brick structure was probably occupied for some time and then used as a foundation for the third major architectural configuration—the Room 1/2/3 complex built of baked brick (Figures 4.16, 8.2, and 13.40).

If one were to examine the faunal data alone without considering other archaeological information, one might plot average density of bone against absolute elevation in 10 cm intervals. Such an exercise, which can be roughly accomplished by manipulating the data in Table 7.3, reveals two significant peaks corresponding with Lots 3171 and and 3151, two troughs matching the lowest and uppermost street surfaces (Lots 3172 and 3048), and otherwise an average density ranging between about 100 and 200 bones per cubic meter. This is the same general pattern one sees if, more realistically, one plots density of bone against excavation unit as in Figure 7.8.

A better understanding of the street deposits is gained by considering together the nature of the excavation units and the characteristics of their faunal component. Based on this sort of contextual approach, it is possible to identify four broad categories of deposits in Street NS2355 at Harappa: 1) those with very little bone (less than 60 bones/cu.m) or other trash; 2) those with a moderate amount of bone (100–250 bones/cu. m) in loosely consolidated matrix; 3) compacted strata with very high densities of bone (greater than 650 bones/cu.m); and 4) less compacted bone concentrations characterized by articulated skeletons or carcass segments.

The highest concentration of bone documented so far is in Lot 3171, which comprises the earliest Period 3A deposits in the street. Individual fragments are small, averaging 3.2 grams in weight (Table 7.3 and Figure 7.8). This is partly due to the dominance of small bovid bones in the assemblage (Tables 7. 4–7.5) and partly to the high degree of fragmentation of the material. The excavator noted that Lot 3171 was a fairly distinct compact layer ca. 10 cm thick made up of horizontally laid potsherds in hard packed silt. It may thus represent a street surface perhaps contemporary with the construction of the Period 3A buildings almost a meter higher in the east.

High proportions of small bovid and, more generally, medium mammal remains continue to characterize the immediately succeeding strata represented by Lots 3166, 3165, and 3164 (Tables 7.4–7.5). The sizes of fragments are larger, however, (Table 7.3 and Figure 7.8), and the sediment ashy and less compact, suggesting trash deposits from occupations in adjoining structures. Density of bone decreases considerably in Lots 3164 and 3162, although in Lot 3162 average weight per fragment is relatively high, reflecting both larger pieces and the presence of a higher proportion of bovine bone. This lot is described as having "packed nodule and terracotta cake fragments" together with ash and charcoal, and thus it again may have been just below an active street surface.

With Lot 3161 begins another series of deposits with high concentrations of relatively heavy (large) bone fragments. Most of these deposits are loosely packed, with the notable exception of the lower part of Lot 3151 (the lower of the two strata labeled "bone and rubble" in Figure 7.7), which is described in the field notes as "a thick layer of almost concreted rubble, pottery and bone." To date more than 1100 specimens have been analyzed from this lot, with additional material awaiting study. Some of the bones are complete bovine specimens including mandibles and horn cores; this is reflected in the fact that the average specimen weight is among the highest at the site. The olive-green staining of the bone-rich deposits is an indication that organic sludge was a component of this stratum, suggesting that drains or sump pits were no longer operational in this part of the site when the deposits were formed and that sewage was allowed to run in the streets. Like Lot 3171, this concreted rubble may represent a kind of natural pavement formed as the street served traffic and, in this case, as an open sewer.

Table 7.4: Counts of Mammal Bone from Harappa Mound E South, Area C, Street NS2355

Lot	3172	3171	3166	3165	3164	3162	3161	3156	3153	3151	3066	3065	3062	3056	3055	3048
very large	0	0	0	0	0	0	0	0	1	1	0	1	0	1	0	0
large	11	244	72	16	14	50	35	37	200	626	88	90	133	321	84	14
large/medium	14	629	91	17	18	2	22	2	11	198	50	9	117	8	40	0
medium	18	622	291	58	73	63	93	147	188	300	66	22	76	221	44	5
Total	43	1495	454	91	105	115	150	186	400	1125	204	122	326	551	168	19

Material from Lot 3151 has not been completely analyzed.

The bone, sherd and rubble bed of Lot 3151 did not cover the whole of the street, pinching out toward the east against the earlier deposited strata of Lot 3156. This latter lot together with the intervening Lot 3153 yielded the partially articulated skeletons of four dogs—two young, two mature.[5] Bones from these skeletons were also excavated as part of Lot 3161, with an additional single articulating epiphysis from 3066, which like 3151 and 3153 abutted the slopping strata of 3156 in the east (Table 7.5). This distribution underlines the fact that the lots, as excavation units, may not be precisely congruent with single or even discrete multiple depositional units, and thus one can really only deal with them in terms of trends or tendencies and not as absolute measures of human activity. It also indicates, however, that a considerable quantity of debris was dumped into the street at one time, possibly when the Period 3A architecture was filled with trash prior to the construction of the mud-brick walls of Period 3B.

Lot 3066 (the upper "bone and rubble" stratum in Figure 7.7) or perhaps Lot 3065 with its high proportion of large bovine bones may represent the last of the fill deposited in the street before the construction of the Period 3B architectural complex. Lot 3062 comprises a series of street levels which may be contemporary with the earliest phase of Period 3B. Fragment sizes are relatively small (Table 7.3 and Figure 7.8) even though the proportion of bovine bone remains high (Table 7.5). Following these street levels, are a relatively thick series of deposits comprising Lot 3056 that are again stained green presumably with sewage. Unlike 3151, however, they are not tightly compacted. The same is true of the following "upper street levels" included in Lots 3055, 3052, and 3048 that are probably contemporary with the last occupation of the baked-brick Room 1/2/3 complex. The proportion of large mammal, specifically bovine, bone remains high in all of these upper levels, as does the average bone weight (fragment size).

To summarize, high densities of bone can result from packing due to the use of the street as an open sewer and/or by heavy traffic (e.g., Lots 3151 and 3171). Lower densities can be interpreted as reflecting periods of occupation during which trash was scattered in the streets and mixed with other debris and varying amounts of sediment resulting from housekeeping in nearby structures. Very low densities may reflect active maintenance or reconstruction of the street, while the presence of whole or significant portions of animal carcasses (e.g., Lot 3156) suggests that the street may have fallen out of active use as a thoroughfare for some time. Indeed, from this analysis it appears that only during Period 2 (or early Period 3A) and late in Period 3B (contemporary with the baked brick Room 1/2/3 complex) was the street actively maintained or reconstructed, although the fact that the excavation units do not always coincide with depositional units may obscure other episodes of street maintenance.

One question that remains unresolved is whether the bones (and artifacts) in the street were the result of primary, secondary, or even tertiary deposition (Meadow 1980). In other words, were they thrown into the street immediately after consumption, were they swept up from their primary loci and dumped into the street, or were they transferred to the street as a component of fill intentionally deposited there. The second and third possibilities are more likely than the first which means that ravaging of the assemblages by dogs would have taken place before deposition in the street. The facts that whole segments of carcasses were

Table 7.5: Standardized Counts of Fauna from Harappa Mound E South, Area C, Street NS2355

Lot	3172	3171	3166	3165	3164	3162	3161	3156	3153	3151	3066	3065	3062	3056	3055	3048
bovine	1	42	15	5	2	10	5	7	49	124	5	13	20	36	8	3
large cervid	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sus scrofa	0	1	2	0	0	1	0	1	4	5	0	0	0	1	0	0
small cervid	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
small bovid	0	5	3	0	0	1	0	0	1	0	1	1	2	6	0	0
Gaz./Antil.	0	1	0	0	0	1	0	0	0	0	0	0	0	4	0	0
Ovis/Capra	1	82	55	9	7	9	11	6	38	69	5	3	10	35	4	2
large canid	0	2	0	0	0	0	8	47	22	1	1	0	0	1	0	0
Total	2	135	75	14	9	22	24	61	114	199	12	17	32	83	12	5

Standardized counts include only the following skeletal parts: occipital, zygomatic, mandibles and maxilla with teeth, loose dP4 and M3, atlas, axis, sacrum, articular ends of long bones, phalanges, distal scapula, acetabulum area of pelvis, carpals and tarsals; not included are horn core and other skull fragments, mandibles and maxilla fragments without teeth, other loose teeth, other vertebrae, other parts of the scapula and pelvis, ribs, sternum, shaft fragments, unidentified fragments; material from Lot 3151 has not been completely analyzed.

found both in the street and within an adjoining architectural complex and that none of these showed signs of carnivore chewing are evidence that, at least during that (those) depositional episode(s), dogs did not have access to the bones.

A more detailed understanding of the source for and formation of street deposits could be achieved through microstratigraphic stripping of depositional units (working back from an existing section) and piece plotting of uncovered materials. This kind of excavation might also be combined with micromorphological studies of site formation processes (Courty, Goldberg, and Macphail 1989) and determination of the season of death of animals the remains of which came to be included in the deposits (e.g., Wright, Miller and Redding 1980; Lieberman, Deacon, and Meadow 1990). Although time consuming and therefore expensive, such a combination of approaches, if employed in a carefully thought out and strategic fashion, could help unravel the intricacies of occupations that appear discontinuous when one considers only the configurations revealed by the large scale horizontal excavations so necessary for understanding structural complexes from an architectural point of view. Thus, the real value of street excavations lies in their potential for documenting continuity of occupation in the context of fluctuating civic attention to particular quarters where otherwise one might get the impression of episodic change due to the presence of successive and apparently discontinuous architectural configurations.

Conclusion

Although the faunal record is affected by a host of taphonomic factors, it is worth posing questions of that record in an attempt to investigate the processes and behaviors that produced it. To the extent that consistency of pattern characterizes the data, one can have some confidence in the trends revealed, bearing in mind, however, that equifinality is always a possibility.

Overall decrease in body size is a characteristic phenomenon of each of the domestic bovid taxa represented in northwestern South Asia during the neolithic period, although the pattern of size diminution differs in detail for each taxon. Unfortunately, data revealing this decrease is so far limited to one site. With the Harappan phase, bone measurements from a number of sites become available. Comparison of these indicates differences in animal build that could reflect different breeds or different husbandry practices or both.

At Harappa, sheep remains greatly outnumber those of goat, and many of the sheep bones come from animals as heavy, although probably not as tall, as those characteristic of neolithic levels at Mehrgarh. In contrast at Nausharo, sheep appear to be nearly as small as the size reached during chalcolithic Mehrgarh and to a lesser extent outnumber goats. These two strands of evidence are consistent with an interpretation that sheep were a particular focus of animal husbandry at Harappa perhaps for secondary products (wool) as well as for meat and fat.

With cattle a pattern opposite to that for sheep seems to occur. Thus on an overall basis, Harappa boasts taller lighter animals and Nausharo shorter heavier ones. This again may indicate the development of specific breeds in the two areas, although such an hypothesis requires testing through analysis of material from other sites and time periods particularly in the Punjab. For goats the situation is less clear because of small sample sizes, although there is marked diversity in animal height reflected in the few length measurements available from Nausharo. For all taxa, examination of kill-off patterns is the necessary next step in investigating potential differences in animal husbandry practices.

Given the fact that numbers of measurable bones are small absolutely as well as in relation to the size of the assemblages analyzed, it has been necessary to group data from all strata of the different phases in order to investigate questions relating to animal size and proportions. This requirement has reduced the resolution of the results and perhaps created an impression of punctuated change where in fact there may have been continuity. Other types of analyses that use a greater proportion of the analyzed fauna provide the opportunity to use the excavation unit as the minimal analytical unit. This has been the case with the analysis of the street deposits at Harappa.

Based on calculations of the number of bones per cubic meter of deposit, variability in the concentration of bone excavated from Street NS2355 could be monitored. Although resolution was not as good as it could have been if individual strata had been carefully stripped back from an existing section, it was possible to define different episodes in the life of the street and relate them to the sequence of architectural change in the area. A principal conclusion must be that units with the greatest bone density need not correlate specifically with major dumping episodes but merely with processes that tend to concentrate bone (and other artifactual material) by removing the sediment from the deposit. Packed bone and rubble can form a kind of natural pavement particularly if the street as a whole is used as a drain for the surrounding area. Episodes of dumping are better reflected by the presence of articulated skeletons or carcass segments. This situation, particularly if the bones lack any signs of gnawing, indicates the absence of scavenging carnivores from the area or the rapid covering of the remains by sediment.

In addition to bone density, mean fragment size was also calculated for each excavation unit in the street. The plot of the resulting statistics in Figure 7.8 shows a general trend toward larger (i.e., heavier) pieces in the later levels. This could be due to decreasing fragmentation, increasing numbers of bones from larger animals, or both. An examination of the bone count statistics reported in Tables 7.4 and 7.5 shows that larger mammal (i.e., bovine) remains are increasingly frequent in the later levels. Whether this, in fact, reflects an increasing focus on cattle (*Bos* and *Bubalus*) through the course of the Harappan phase remains to be tested by comparison with sequences of faunal remains from other areas of Harappa.

Notes

[1] One explanation for this pattern may be that in the earlier period the villagers of Balakot obtained marine resources such as unbroken mollusc shells and the occasional fish through trade with distinct fishing and gathering communities the existence of which is not otherwise attested in the settlements so far excavated. With the Integration Era of the Indus Tradition (Shaffer 1991), these fisher folk (ichthyofagoi) became fully incorporated into Harappan society and served as major sources of fish and molluscs for food and for ornaments (Kenoyer 1983). A test of this hypothesis would involve locating and excavating a sequence of coastal shell middens to document the course of marine adaptations along the Makran coast through late prehistoric period (Tosi 1986).

[2] The terminology used is basically that of Jarrige, but see also Kenoyer (1991) and Shaffer (1991).

[3] The faunal materials from Mehrgarh and Nausharo were studied at the field camp of the French Archaeological Mission where they are currently stored. Of 120 *Bos*, 75 *Ovis*, and 51 *Capra* specimens measured from Nausharo, 73, 35, and 16 measurements, respectively, were used to compile Figures 7.1–7.4.

[4] The faunal materials from Harappa were studied in part at the site and in part in the Zooarchaeology Laboratory of the Peabody Museum where they are now stored. Some 227 *Bos*, 126 *Ovis*, and 35 *Capra* specimens were measured to provide the 139, 75, and 25 dimensions, respectively, employed to make up Figures 7.1, 7.2, 7.5, and 7.6.

[5] The dogs of Harappa also probably ravaged faunal assemblages available to them, although only about 20 specimens of the 5,554 analyzed from the street deposits show clear signs of carnivore gnawing.

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Cover art: Bowl on Stand H88-1002/192-17 associated with Burial 194a
in Harappan Phase Cemetery (see Figure 13.18).

8

Fish Resources in an Early Urban Context at Harappa

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Fishing is often neglected in studies of urban societies. This is unfortunate as the study of fish can reveal aspects of subsistence, regional trade, access to resources, and social organization. Coastal and inland relationships can be examined by considering marine and riverine species variation. Seasonal indicators can suggest whether fishing was a full-time or part-time activity. Material from dump and domestic contexts excavated from the inland, urban center of Harappa is used to examine these issues. Limited comparison with the contemporary coastal settlement of Balakot is also presented.

Research during the last 15 years has begun to focus on quantification of the subsistence base during the Harappan Phase of the Indus Tradition. Richard Meadow (1979, 1986, 1989) has focused on a variety of problems concerning mammalian fauna, and there is considerable work in progress on agricultural systems (Costantini 1981; 1984; Reddy, Chapter 10 in this volume; Miller 1987, Chapter 9 in this volume; Weber 1992). The study of fish remains, however, has been virtually ignored in South Asian archaeology. With the exception of material from the coastal site of Balakot (Figure 8.1) that was sorted in a preliminary fashion by Camm Swift and Virginia Butler, no concerted effort has been made to analyze the numerous fish remains from many South Asian sites. To date, few subsistence studies have taken fish into account, although through the years, significant quantities of fish have been recovered (see Meadow 1979 for an exception).

This paper attempts to outline the use of fish within an urban context and to present a predictive model of fish disposal based on the ethnographic literature. Fish remains from a small area of the 1990 Harappa excavations (Figure 8.2) are examined in an effort to understand the use of fish in an urban center. Comparison with the Harappan coastal settlement of Balakot also is presented in order to assess regional differences in the utilization of fish resources.

The study of fish within an urban context can assist in the elucidation of a variety of topics, such as: (1) subsistence, (2) trade, and (3) seasonality. Variation in subsistence can be examined on several levels primarily relating to intra-site and inter-site differences. Analysis of intra-site variation can lead to an understanding of how a site is supported from its surrounding hinterland. Differences within an urban center may be related to varying subsistence practices as well as to differential access to particular resources, perhaps related to aspects of social structure. Inter-site studies allow one to examine variation between sites as they relate to size and function as well as to differing local ecosystems. In order to learn how fisheries were integrated with agricultural cycles, seasonality estimates are necessary. Issues of trade and exchange can be examined with fish remains, as many fish inhabit specific micro-habitats in the aquatic system (Wheeler and Jones 1989). Fish remains will therefore be particularly useful for investigating

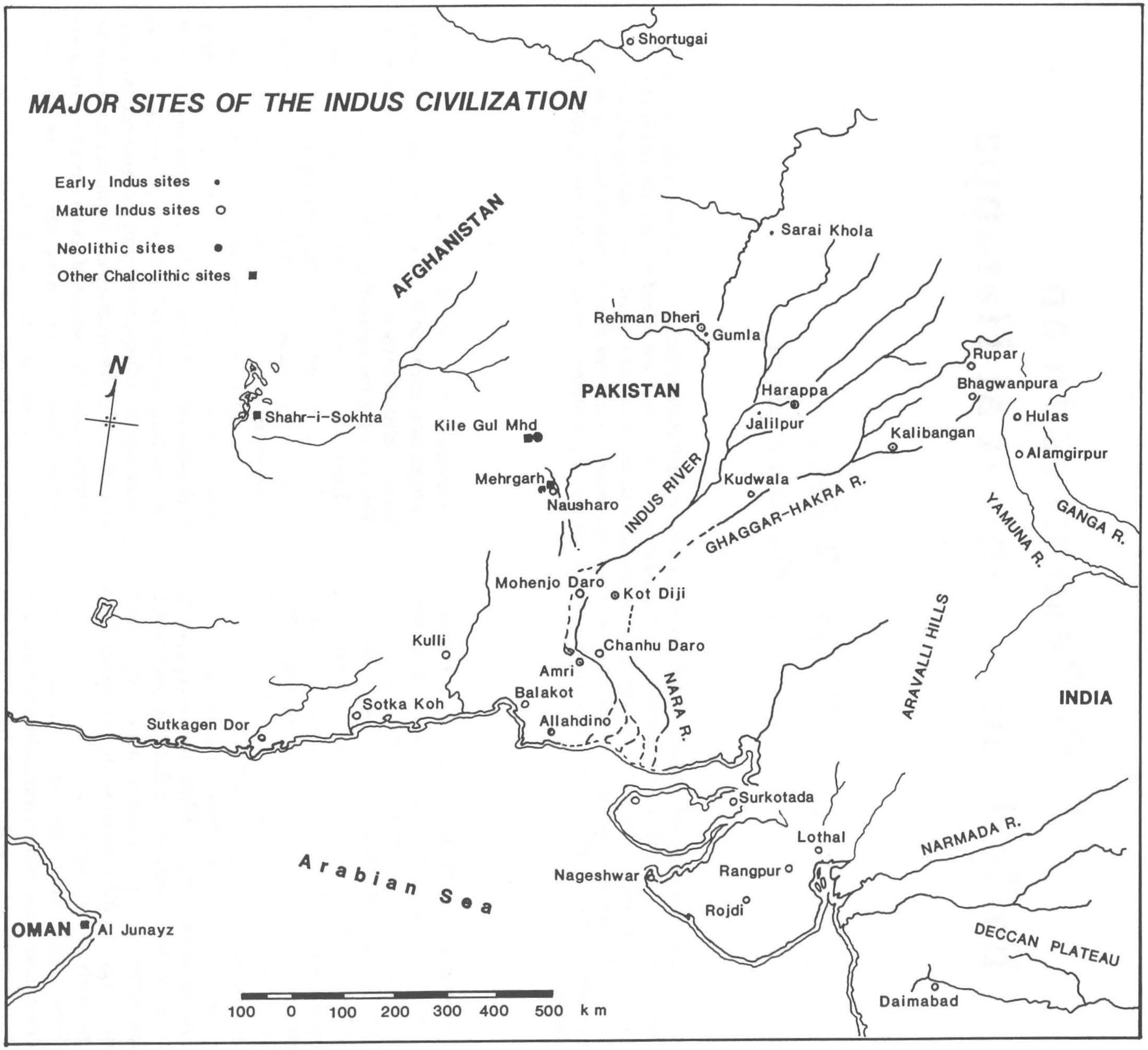

Figure 8.1: Map showing locations of major sites of the Indus Civilization.

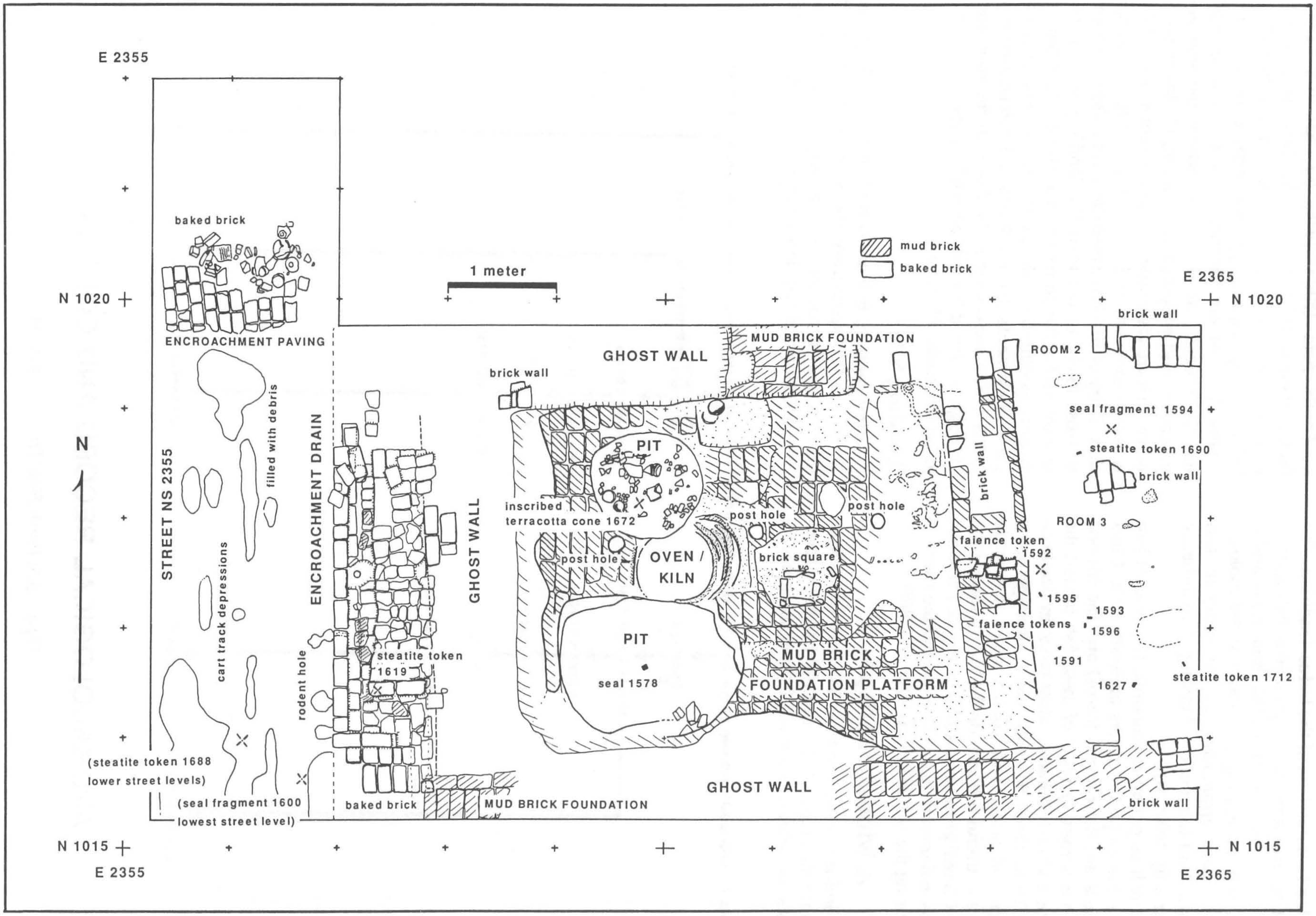

Figure 8.2: Harappa 1990: Plan of house structure (Rooms 1-3) and upper street levels (Street NS2355) in Area C on the southern slope of Mound E.

coastal-inland interactions of the Indus Tradition. The identification and analysis of particular fish species will permit the location of exploitation areas and a reconstruction of appropriate capture technology. Ultimately, these approaches to the study of fish remains will lead to an understanding of an industry that is currently unknown.

Several fish of potential economic importance live within the contemporary rivers of South Asia. Chief among these are the cyprids (carps) and the silurids (catfish). Numerous varieties of these fish inhabit the river Indus and its tributaries. Most range in size from less than 10 to about 50 centimeters, although some large carps and catfish will reach a meter or more in length. Other useful fish include the Indian shad (*Hilsa ilisha*), which will grow up to 40 cm in length. These fish are of seasonal importance as they ascend the rivers to spawn during the winter season (Qureshi 1965).

A Model of Disposal

A preliminary model of how fish may move from capture into the archaeological record has been developed based on ethnographies of fishing communities in South Asia (Khin 1948; Raychaudhuri 1980; Suryanarayana 1977; Tietze 1985). This movement is divided into four systemic states (cf. Schiffer 1972, 1976): (1) the aquatic system (marine or riverine) where the fish are procured; (2) the landing site, usually a beach or riverbank, where the fish are processed and prepared for market; (3) the market, where fish are distributed to the consumer; and (4) the domestic area, where food is prepared for consumption. Entry of fish bone into the archaeological record is most likely to occur at the landing area, in the market, and in the domestic area. This model attempts to deal specifically with the potential combinations of skeletal elements that are likely to be deposited as a catch of fish moves from the fisher to the consumer through the dried/salted fish trade (Figure 8.3) or the fresh fish trade (Figure 8.4).

Landing Site

After capture, fish are sorted by size and species. Particular fish species are always sought as they will bring a higher market price. Sorting is also based on the condition and appearance of the fish. Two forms of

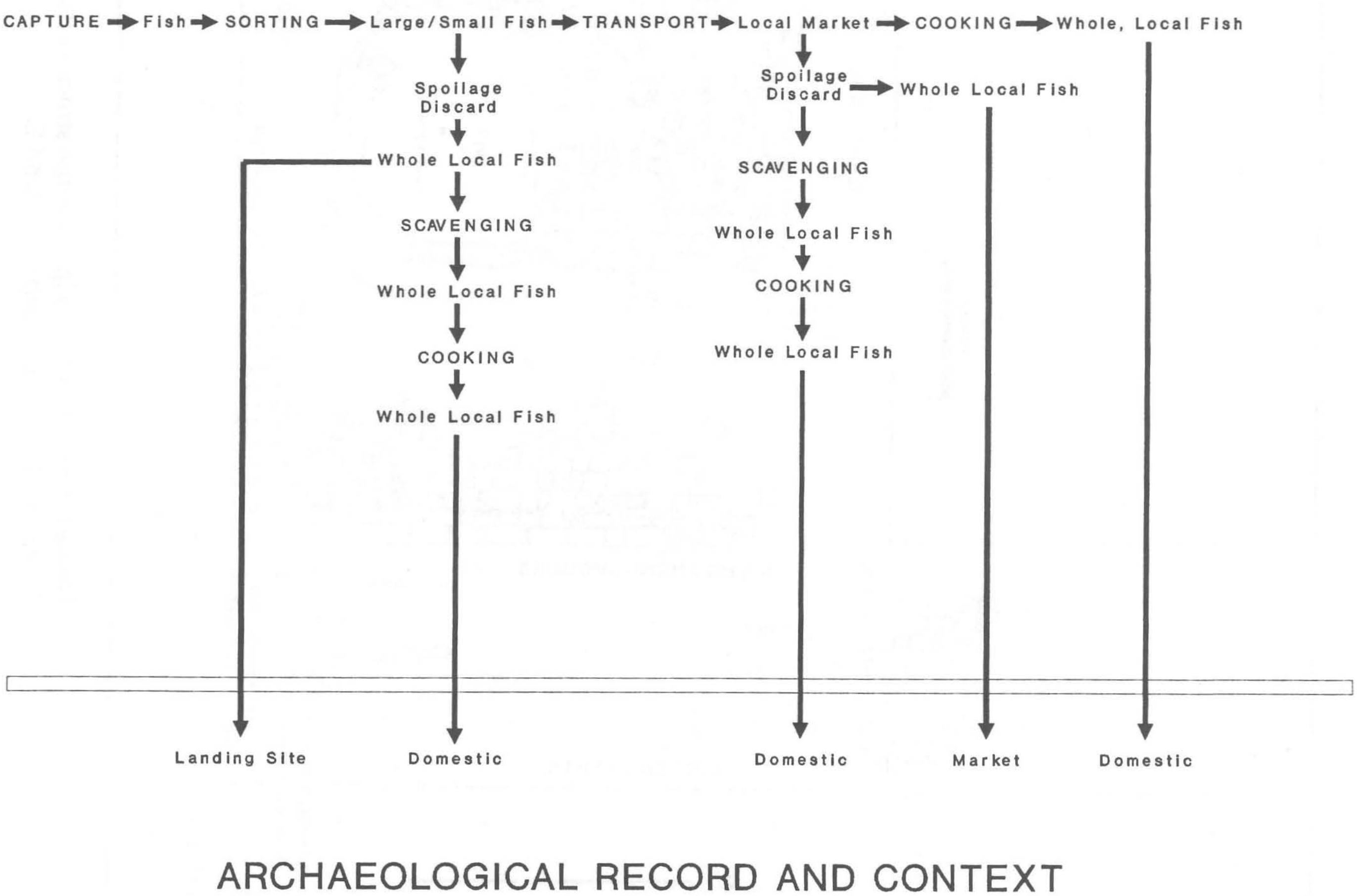

Figure 8.3: Fresh Fish Trade flow chart.

processing can be performed after sorting: fish can be sun-dried or salted, or taken directly to the market in a fresh condition. The major consideration for this stage is distance to market: fresh fish will be taken to local markets, while dried/salted fish will be taken to distant markets.

Dried Fish Trade

Small fish move immediately to sun-drying or salting (more recent developments encourage the use of ice for all fish). Thus, all bone elements are retained within the fish as it moves to the market. However, large fish will usually be butchered, as the meat cannot be adequately dried due to size and otherwise would spoil before reaching the consumer. Often during butchery the cranium will be separated from the body and the entrails removed.

During this latter procedure the pectoral and pelvic girdles may be removed. In contrast, vertebrae are often left in the fish when dried or salted and transported to a regional (distant) market. Thus, one would expect to find the remains of heads and pectoral/pelvic girdles in landing areas when large fish are salted and dried. Decay during the salting/drying stage can cause disposal into the archaeological record; however, human scavenging of both butchered slabs of large fish and whole small fish at the landing site will move these materials directly to the domestic sphere with its own characteristic skeletal part signature.

Market

Markets can be divided into two categories: local markets, near the source of the fish (landing site), and distant markets, extralocal areas to which fish are traded. Local fresh fish are taken directly to the market and distributed to the consumer; varieties of whole fish may be discarded here due to spoilage. Again, scavenging of this discard will move whole, local fish into the domestic sphere. Preparation and cooking of this waste leads to the deposition of bones in the archaeological record at the level of the domestic sphere. Fish are dried and salted for transport to regional or non-local markets. Small fish retain all

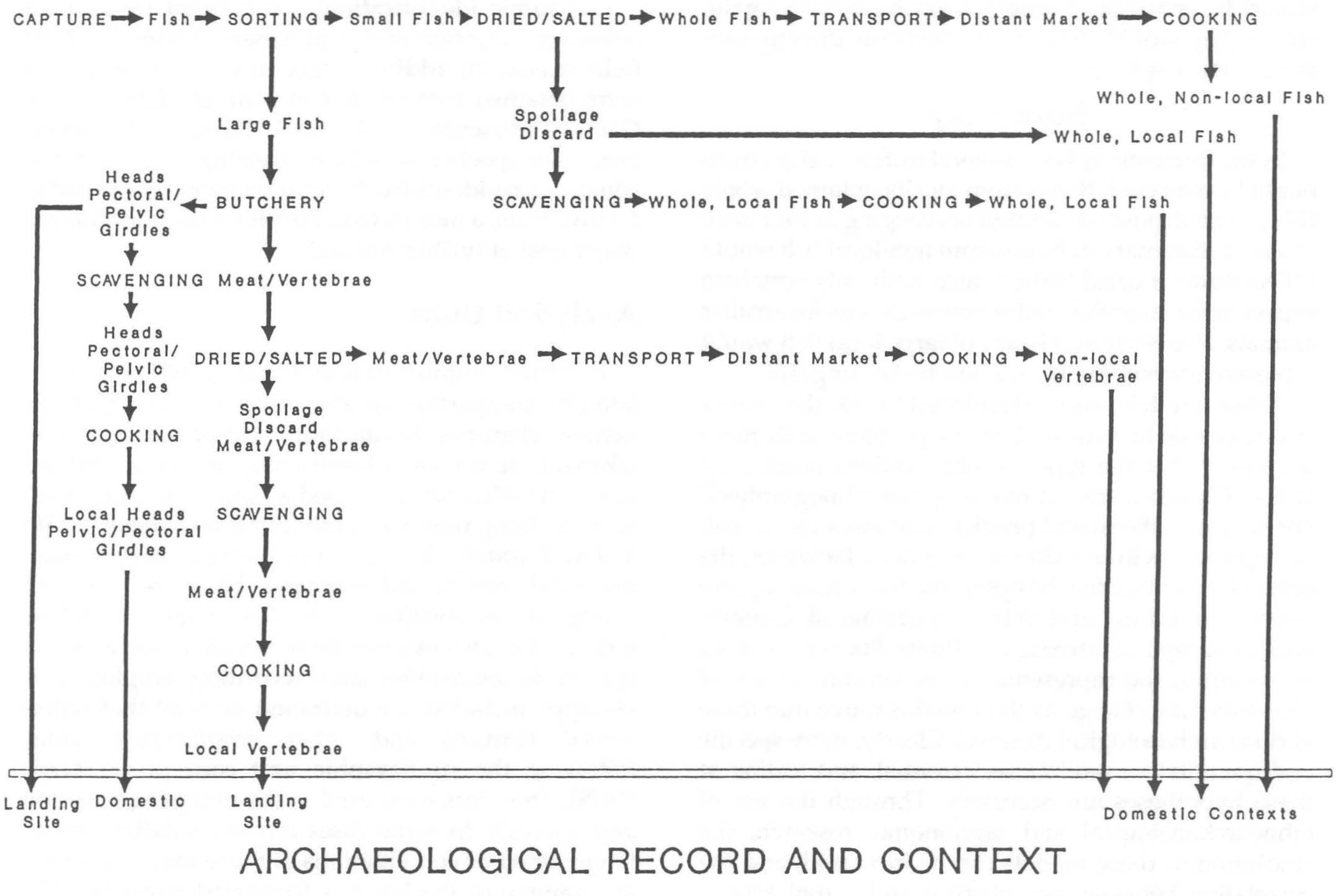

Figure 8.4: Dried Fish Trade flow chart.

bones, while large fish are represented by vertebrae, fin rays and ribs. The important variable here is the distinct element composition and non-local varieties of dried fish that are available to the consumer.

Hypothetical Faunal Assemblages

Context, fish species (local, non-local), and element (skeletal part) representation allow one to evaluate transport/processing mechanisms as the fish move from the fisher to the consumer. If the fish are sorted, processed and dried on the boats while still in the aquatic system, none of the discard will reach the archaeological record. At the landing site, butchery of large fish for salting/drying and spoilage from drying/salting are the primary sources of bones in the archaeological record: (1) small fish would be represented by whole local fish from spoilage, while (2) large local fish would be represented by cranial and pectoral/pelvic elements from butchery and vertebrae from spoilage. As noted previously, however, if people are scavenging at the landing site, these fish remains may move directly to the domestic sphere. At markets, the major source of archaeological bone would be spoilage of whole, local fresh fish. Again, scavenging would move these elements directly into the domestic sphere.

Summary

In the domestic sphere, several different signatures might be expected. Bones from locally obtained whole fish can be deposited through scavenging or exchange at a fresh fish market. Bones from non-local fish would reflect trade of dried/salted catch with only vertebrae expected for large fish and whole skeletons for smaller animals. Vertebrae and heads of large local fish would represent scavenging from a nearby landing site.

These models were developed from the extant ethnographic literature. A major problem with these sources is that the types of observations needed by archaeologists were not made by the ethnographers. For example, the model predicts that most refuse will be deposited within a domestic context. However, the process by which fish bones move from cooking into household refuse and into archaeological contexts such as sump pits, streets, and house floors is unclear. In addition, the representation of certain classes of elements may change as the remains move into these various archaeological contexts. Clearly, more specific and quantitative models are essential, and testing of these hypotheses are necessary. Through the use of ethnoarchaeological and taphonomic research, the resolution of these models can be increased, and the correlation between hypothetical and actual assemblages can be evaluated.

Methodology

Recovery

Usually all faunal samples can be divided into two groups: whole excavation unit samples and partial unit samples usually from fine-screening or flotation. At Harappa, the recovery of subsistence data has been of major concern. Many whole unit samples, therefore, were screened through fine-mesh of 2 mm and thus represent a fine-screened sample. In addition, selected samples were subjected to flotation, with the result that several smaller bone fragments and fish vertebrae were recovered.

Analytical procedure

In many cases, identification to genus or species has been possible. The scientific nomenclature used comes from a variety of sources including Mirza (1975), Qureshi (1965), and Ahmad, Khan, and Mirza (1976). Provenience, element, condition, size or age category, and presence of burning or fracture as well as the number and location of cutmarks were also recorded for each specimen.

Taxonomic identifications were aided by a small reference collection of fish processed during the 1990 field season. In addition, several freshwater species were obtained through a loan from the Los Angeles County Museum of Natural History. However, numerous specimens in the archaeological assemblage could not be identified beyond element and possible family. Thus, a more adequate reference collection is a major goal of further research.

Analytical Units

Minimum number of individuals (MNI) was calculated by comparing left and right sides of particular skeletal elements. In addition, size of elements was taken into account to achieve a more accurate estimate. Grayson (1984) has discussed a variety of procedures for examining number of identified specimens (NISP) and MNI counts. As the unit of aggregation decreases, the MNI count will increase. Thus, in cases of contiguous excavation units, MNI counts could be inflated if treated as separate aggregates. However, the system of excavation and recording employed at Harappa included the definition of 'lots' that represented features and other stratigraphic units, following the stratigraphic unit concept of Harris (1979). Thus, lots were used as the unit of aggregation and analysis. In some cases lots are subdivisions of larger strata or combinations of more than one strata; an example of the latter is laminated street fill. The refitting of mammal bone and rejoining of pottery

fragments will be used at a later stage of analysis to redefine the analytical units.

Fish Remains from Harappa

Fish remains were recovered from earlier excavations at Harappa. Prashad (1936) reported several fish bones from the excavations of Vats during the 1920s and 1930s (Vats 1940). However, these were unidentified to species, except for a pectoral spine "probably" from the catfish *Rita rita*.

The 1990 sample reported here is somewhat greater than 1500 fragments of which the total number of identified specimens (NISP) is 856. Over 700 of the smaller pieces in this sample could not be identified beyond the categories: 'fish bone' or 'rib/spine/ray fragment.' Fish bone differs from mammal bone in that it is relatively light and fibrous (Wheeler and Jones 1989:87-88). When poorly preserved, the bone will often spall or flake off and form 'bone dust.' Small ribs, spines, and fin rays are fragile and will fracture into numerous pieces, making the identification of specific taxa extremely difficult.

Of the 856 identified specimens (Figure 8.5), almost half are silurids (catfish). *Wallago attu* accounts for 42% of the total assemblage. In addition, *Mystus* sp. is represented by over 1% of the specimens, while the Ariidae family of marine catfish is attested by a single fragment (0.1%). Unidentified silurids comprise about 4% of the total sample. Carps are also significantly represented. *Labeo* sp. accounts for 6.5% of the specimens and unidentified carp for another 6.5%.

Over 25% of the NISP currently remains unidentified to genus or species. This situation represents the lack of an adequate reference collection. Of these unidentified remains, several minuscule vertebrae were recovered from flotation; these may represent smaller carps or shad.

Context of Fish Remains

Kenoyer (Chapter 4 in this volume) has developed a model that identifies some of the processes responsible for urban growth at Harappa. This model is based on a shifting occupation during the several chronological periods at the site. During Periods 1 and 2, initial growth from a small site to a larger community occurred. At the beginning of Period 3A, expansion of the settlement took place on Mound E. Subsequently, occupation shifted or expanded to Mound AB. In concert with this shift was a lack of civic maintenance and resulting garbage accumulation on Mound E. Kenoyer suggests that this shift may correspond to the development of merchant ruling classes or ruling elites and new socio-economic/political organizations. Subsequently, renewal of Mound E during Period 3B may correspond to decay on Mound AB. During Period 3C, evidence suggests extensive congestion in many areas of the site and a general lack of civic control.

The analysis reported below centers on several samples brought back to the United States from the 1990 excavations, although only the material associated with a single structure are discussed in any detail

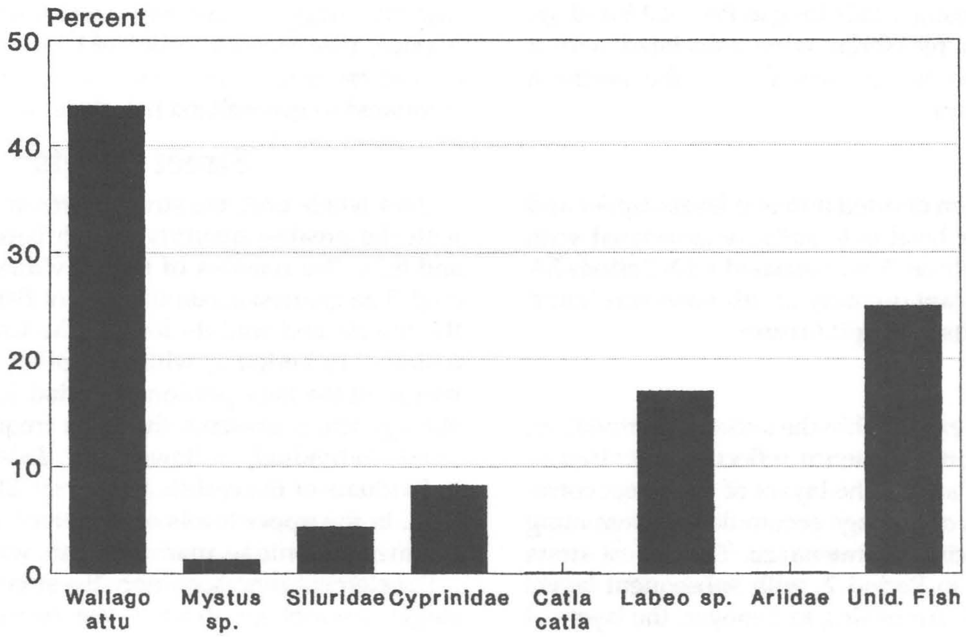

Figure 8.5: Harappa 1990 fish remains (Number of Individual Specimens = 856).

(Figure 8.2). Included are a mud-brick platform in Room 1, two associated rooms (Rooms 2 and 3), several features (N and S Pits, Hearth/Kiln, Brick Square, Brick Structure), and a nearby street. Although several stratigraphic units exist within the area, they have been collapsed into groups (unless otherwise noted) for this preliminary evaluation which includes species and element representation, fish size, and seasonality.

Room 1 (Platform)

The platform appears to be associated with the occupation of the adjacent rooms (2 and 3), although the exact relationship is currently unclear as deposits beneath the platforms were not excavated. Overlying the platform was a gray ashy deposit that contained much of the fish bone. This deposit probably is associated with the decline of Mound E during Period 3A. Two pits (North Pit and South Pit) were dug into the platform and thus post-date its construction. Additionally, the North Pit truncates the hearth/kiln feature in the center of the platform.

A few fragmentary fish bones were recovered from posthole fill. This fill may be associated with abandonment of the platform area. The postholes are thought to represent some form of superstructure over the platform. A few fish bones were recovered from a shallow pit inside the platform area that was filled with ashy debris where later a square structure made of brick bats was constructed. Its function is unknown.

Room 2

This room is thought to belong to Period 3A and 3B. Most of the fish recovered were associated with a Period 3A hearth feature found near the northern portion of the room.

Room 3

Room 3 has been divided into two levels: upper and lower. The lower level is tentatively associated with Period 2. Upper Room 3 is associated with Periods 3A and 3B. A significant quantity of fish bone was found within fill deposits and a pit feature.

Street

Several layers exist within the street and provide an excellent diachronic sequence reflecting activities in the surrounding areas. The layers of the street correspond to periods of garbage accumulation alternating with periods of civic maintenance. The lowest strata can be assigned to Period 2, with subsequent layers being of Period 3. According to Kenoyer, the layers of extensive garbage accumulation should correspond to the decline of Mound E during later Period 3A.

Species and Element Representation from the Whole Area

Based solely on cranial remains, the MNI is 137 (Figure 8.6). The dominant fish within these deposits is the catfish, *Wallago attu*, followed by the carp, *Labeo* sp. A few individuals of another catfish, *Mystus* sp., occur in: (1) the upper layers of Room 3, (2) deposits overlying the platform, and (3) the street level.

An individual of the family *Ariidae* (marine catfish) was recovered from the street levels. Marine catfish are not part of the local fauna and could only have been brought from the marine coastal areas, perhaps through trade.

Two concentrations of individuals are readily apparent: in the street levels and within Room 3. Another concentration occurs within the gray ashy layer that overlies the hearth/kiln feature in the center of the mud-brick platform.

Comparison of the frequency and distribution of elements reveals the general predominance of cranial remains as compared to vertebrae and pectoral/dorsal spines (Figure 8.7). This situation is particularly evident from the street levels and Room 3. A fish has approximately 70 bones in the cranium, although only 50 are usually recovered in archaeological samples (based on personal experience). Number of vertebrae will vary, but a moderate-sized *Wallago attu* has 70 while *Labeo* sp. possesses 45. Thus, if all bones were equally well represented, a skull:vertebra ratio of from about 1:1.4 (for *Wallago attu*) to 1:0.9 (*Labeo* sp.) would be expected. However, from these deposits, a ratio of 1:0.5 occurs. Flotation and fine-screening of the deposits suggest recovery techniques can not be blamed. (See Stewart 1989:80-81 for a similar discussion of ratios of archaeologically recovered elements compared to generalized fish skeletons.)

Street Levels

As a whole unit, the street represents one the areas with the greatest quantity of fish bones (Figures 8.6 and 8.7). The remains of 68 individuals were recovered. The greatest accumulations of fish bone occur in the lowest and middle levels. The lowest levels are assigned to Period 2, while the other concentrations represent the later portion of Period 3A. In most lots, *Wallago attu* represents the most frequently encountered individual, followed by *Labeo* sp. A few individuals of the catfish *Mystus* sp. also were recovered. In the upper levels of the street, a single cranial fragment of Ariidae, marine catfish, was found.

For element representation, the street is treated as a single assemblage; most of the remains came from three lots (excavation units) near the base of the street (Figure 8.8) and thus belong to Period 3A. Cranial

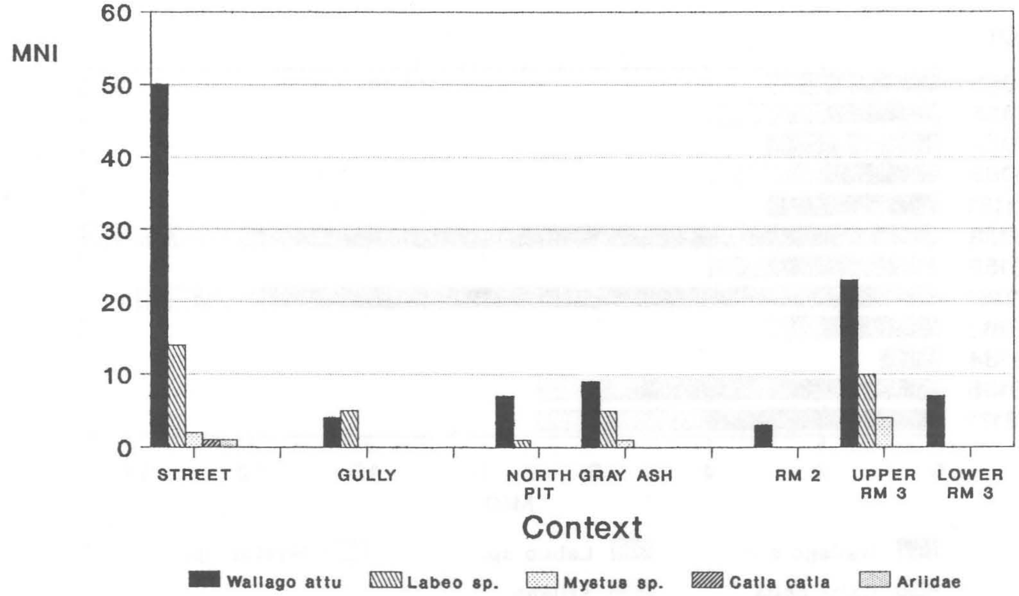

Figure 8.6: Species variation (Minimum Number of Individuals = 137) in Street NS2355 and Rooms 1-3 on south side of Mound E.

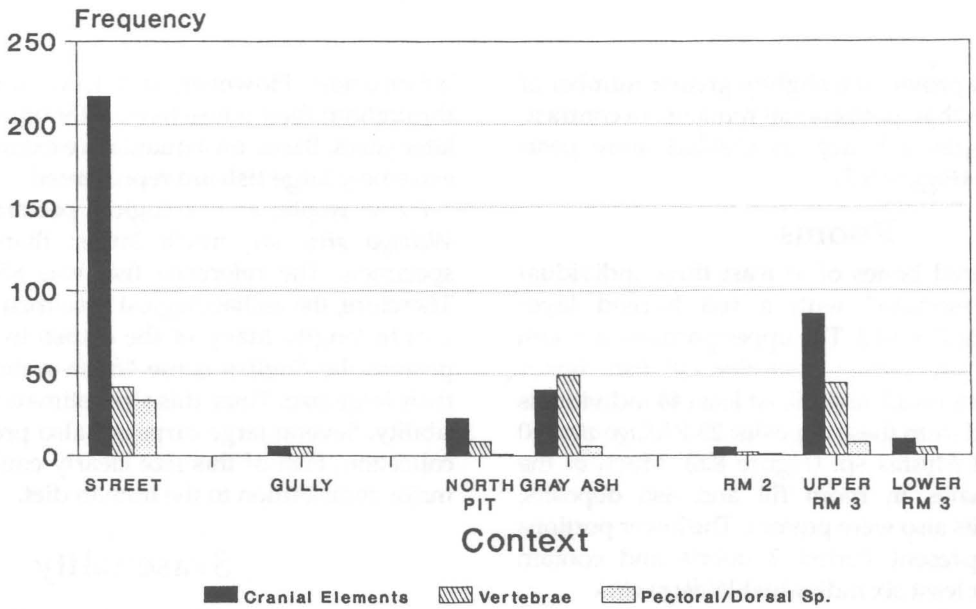

Figure 8.7: Bone element representation in Street NS2355 and Rooms 1-3 on south side of Mound E (NISP = 614).

elements are represented to a much greater degree than post-cranial elements.

Mud-brick Platform Area (Room 1)

No fish bones were recovered from the South Pit or the hearth/kiln feature in the platform area (Room 1). Additionally, no fish bones appear to be associated with the first use of the mud-brick platform. The North Pit contained bones from at least seven individuals: six *Wallago attu* and a single *Labeo* sp. The overlying gray ash yielded the remains of at least fifteen individuals: nine *Wallago attu,* five *Labeo* sp. and a single *Mystus* sp. (Figure 8.6).

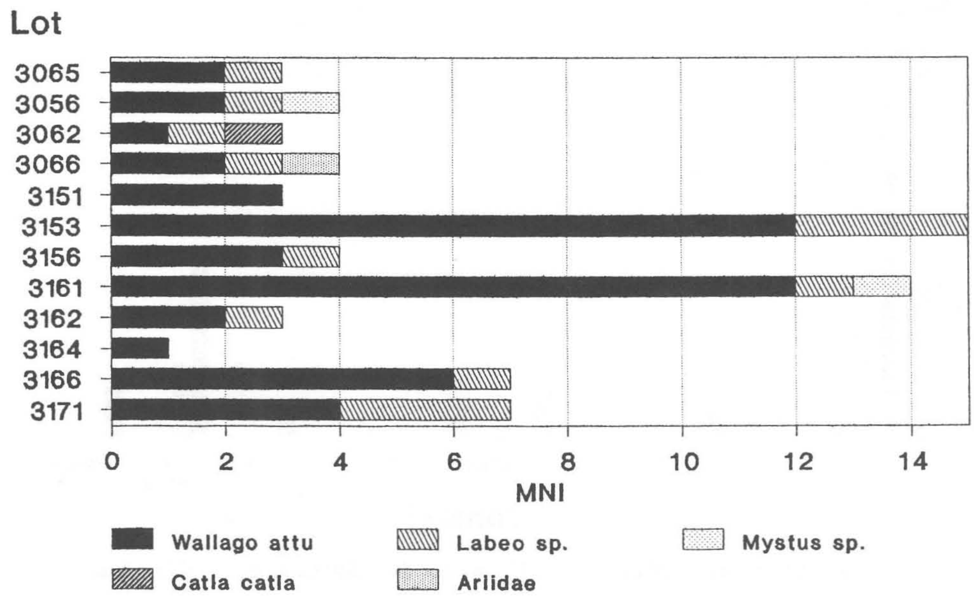

Figure 8.8: Species variation (Minimum Number of Individuals = 68) in Street NS2355; oldest lots occur at the bottom of the graph.

The North Pit provided a slightly greater number of cranial elements than post-cranial remains. In contrast, the overlying gray ash deposit yielded more post-cranial remains (Figure 8.7).

Rooms

Room 2 yielded bones of at least three individual *Wallago attu* associated with a red burned layer deposited during Period 3. The upper portions of Room 3 provided a significant quantity of fish bones attributed to Periods 3A and 3B. At least 44 individuals can be identified from these deposits: 23 *Wallago attu*, 10 *Labeo* sp. and 4 *Mystus* sp. (Figure 8.6). Much of the material originates in room fill and ash deposits, although two pits also were present. The lower portions of Room 3 represent Period 2 debris and contain remains from at least six individual *Wallago attu*.

No significant differences in cranial and post-cranial remains are seen in Room 2 (Figure 8.7). In the upper levels of Room 3, cranial elements again outnumber post-cranial remains, although not to such a degree as in the street. In the lower portions of Room 3, no significant differences occur between these groups of elements.

Size of Fish

No quantitative data exist to accurately estimate the size and meat weight of the fish taxa identified from Harappa. Further research is necessary to obtain this information. However, fish have sustained growth throughout their entire lives, although it diminishes in later years. Based on a qualitative examination, several extremely large fish are represented.

For example, archaeological pectoral fin spines of *Wallago attu* are much larger than the reference specimen. The reference fish was 85 cm in length. Therefore, the archaeological specimen could approach 2 m in length. Many of the catfish in the river Indus possess the English name "fresh-water shark" due to their large size. Thus, this size estimate is not an impossibility. Several large carps are also present within the collection. Fish of this size clearly could have made a major contribution to the human diet.

Seasonality

Incremental growth structures allow an adequate estimate of the season of death in animals. In fish, these structures often are found in otoliths and vertebrae, as well as in the pectoral spines of silurids (Brewer 1987, 1989). However, for any substantive statements to be made, further research must be conducted to understand seasonal growth of those species that are found within the archaeological assemblage.

Interpretation

Due to the preliminary nature of this analysis and the limitations of the reference collection, only initial

interpretations can be made. Nevertheless, given the excellent context of the data and its association, these statements are not entirely speculative.

The study of fish remains from the rooms of the house to the east of Street NS2355 reflects the changing use of space through time. Lower deposits of Room 3 possess some fish remains. These probably represent domestic debris. After the hearth/kiln area and the mud-brick platform of Room 1 were abandoned, fish bones were deposited over the top of the platform in a gray ashy stratum. In addition, fish bones were recovered from the North Pit that truncated part of the hearth/kiln. The great increase in fish remains in Room 3 may be associated with use as a dump area during Period 3A.

According to the model presented at the beginning of this paper, most fish bones should be deposited as domestic debris in particular patterns of element and species compositions. Most of the fish found in this collection are locally available, suggesting that the meat was obtained fresh. However, the single cranial fragment of Ariidae, marine catfish, suggests that some dried fish was brought into Harappa from the distant coast. The fact that this cranial fragment is from a small individual also is predicted by the model. Coastal-interior trade of marine shell within the Indus Valley is already known (Dales and Kenoyer 1977; Kenoyer 1983). Further analysis of the unstudied portion of the 1990 sample as well as samples from previous seasons will help to further elucidate this question of the fish trade.

Other archaeological patterns are not as easily intelligible based on the hypothetical assemblages predicted by the model. The elements in Rooms 2 and 3, the gray ash deposit, and the North Pit do suggest fresh fish trade, as most of the cranial and post-cranial elements occur in roughly equal numbers. One would expect cranial remains to predominate in the households of individuals scavenging from a landing site processing large dried fish. However, the great abundance of cranial fragments in association with a moderate number of vertebrae in the street deposits is not fully predicted by the model. This is due to the fact that movement of bones can occur from one archaeological context to another, such as movement from garbage pits or household debris from several surrounding households into the street.

If scavenging were being carried out, one would not expect the proportion of cranial remains to be much higher than vertebrae. However, street debris probably represents the combination of trash from several households; thus, a pure signature of scavenging has been obscured. Further taphonomic and ethnoarchaeological studies are necessary to understand the movement of bone elements into the archaeological record and the possible differential attrition of element classes (i.e., Stewart 1989).

Stewart (1989:86-89) has suggested that bone element attrition differs between species recovered from natural deposits of fish remains. For example, carps have a greater abundance of vertebrae compared to cranial elements. In contrast, catfish are represented by a greater quantity of cranial elements compared to post-cranial and vertebral elements. Although such a pattern needs to be substantiated for the Harappan materials, this may help illuminate the various patterns of element distribution.

The technology used to harvest these fish is currently unknown. However, several copper-based metal fish-hooks (Figure 8.9) have been recovered during past excavations at Harappa (Vats 1940) and Mohenjo-daro (Mackay 1938). The use of nets is a much more efficient means to obtain large numbers of fish, and netting is the dominant method of fishing within South Asia today (e.g., Tietze 1985). Snaring large fish with nets is not uncommon, but some extremely large fish may have been dispatched with spears. In addition to hook-and-line fishing, there is some evidence for the use of fish traps or small nets such as those depicted on a painted sherd from Harappa (Figure 8.9).

Further analysis is necessary, but it is suspected that fish were a significant portion of the diet for certain populations at Harappa. The size and quantity of the captured fish imply that fishing was not a limited activity and that considerable effort went into this industry.

Balakot

In order to contrast the use of fish, the site of Balakot is used. Balakot is a small mound situated near the middle of the Khurkera alluvial plain near the southeastern side of Sonmiani Bay (Figure 8.1). This site is about 90 km northwest of Karachi and was excavated for four seasons, between 1973 and 1976, by George Dales of the University of California-Berkeley and the Pakistan Department of Archaeology (Dales 1974a, 1974b, 1976, 1977, 1979, 1986).

Preliminary sorting by Camm Swift and Virginia Butler as well as limited tabulation by Richard Meadow (1979, 1986, 1989) imply that fish account for about 50% of the specimens for the Harappan occupation at Balakot. As the site is located near a bay, its inhabitants had access to a variety of environmental zones, including riverine, estuarine, protected bay and open, deep-water areas. In addition, the marine zone of a tropical area has a much greater diversity of fauna, especially fish.

A great diversity of fauna occurs at Balakot, including rays, croakers, jacks and sharks. But by far

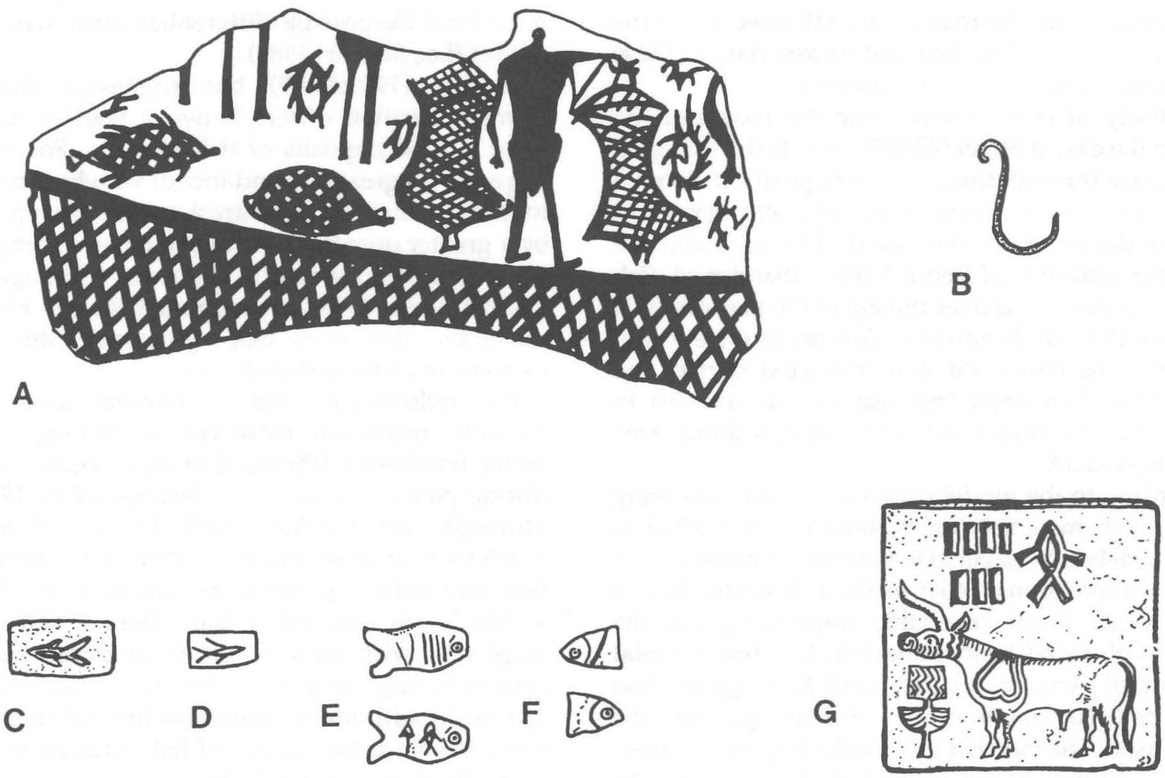

Figure 8.9: Sherd, fishhook, and tokens from Harappa. (A) sherd from Stratum VI, Mound AB, showing fish and human figure with nets or traps (Vats 1940: Pl. LXIX,16; length 11.75 in); (B) copper/bronze fishhook from Mound F, "Great Granary Area, Eastern extension" (Vats 1940: Pl. CXXV,8; length 1.75 in); (C) inscribed fish motif on one face of three-sided faience token from Mound F (Vats 1940: Pl. XCIX, 642; length 0.63 in); (D) inscribed fish motif on one face of three-sided steatite token from Mound F (Vats 1940: Pl. XCVIII, 590; length 0.2 in); (E) obverse and reverse of fish-shaped token in steatite from Mound F (Vats 1940: Pl. XCV,428; length 0.6 in); (F) obverse and reverse of head of fish-shaped token in steatite from unknown provenience (Vats 1940: Pl. XCVII,560; size not stated); (G) unicorn seal of steatite with fish sign from Mound F (Vats 1940: Pl. LXXXIV, a = LXXXV,9; 1.7 in square); all redrawn from Vats (1940) by J.M. Kenoyer.

the most abundant fish is *Pomadasys hasta* or the 'sua' as it is known locally. Currently, MNI estimates of this fish approach 1,500. The fish is estuarine and may represent a particular emphasis on this environment, perhaps during the winter monsoon season when marine fishers rarely will venture out into the open ocean.

Conclusions

Fish appear to have been an important protein source for some populations of the Harappan civilization. Further analysis at Harappa will help identify if there were varying uses of fish in different areas of the site. This intra-site variation may represent differential use of certain resources, probably by various segments of the population. Also there is limited evidence to suggest a marine-interior trade in foodstuffs. Most importantly, it must be emphasized that these fish are not small animals; several from Harappa approach two meters in length, which represents a substantial source of protein.

Inter-site variation is illustrated by the comparison of Balakot with Harappa. Balakot is a small, rural settlement along the marine coast. It appears that nearly 50% of the bones are of marine fish, particularly a single estuarine species.

Kenoyer (1991) has suggested that a major factor leading to the establishment of the integration of the regional sites into an urban society lies in the diversified resource base. During the Harappan phase of the Integration Era (Shaffer 1991), a variety of subsistence strategies were used to support the various communities, urban centers, and the region as a whole. The

fishing industry was an important part of this diversified approach to subsistence. Based on the high numbers of individuals represented even in the small areas excavated as well as the large size of some of the individual fish, it is clear that an active and sophisticated fishing industry was present during the Harappan period.

Acknowledgements

I would like to acknowledge the support of Drs. J. Mark Kenoyer, George Dales, and Richard Meadow. All have been extremely supportive since I become interested in South Asian fish remains. I would especially like to acknowledge Mark Kenoyer for his help and encouragement in starting me down a career path completely different from that I had envisioned. I also would like to thank Mark Kenoyer, Linda Kohlstaedt, Richard Meadow, and Heather Miller for their editorial assistance in this endeavor. Seetha Reddy offered invaluable comments on the use of ethnographic information for the fish bone disposal models.

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Cover art: Bowl on Stand H88-1002/192-17 associated with Burial 194a
in Harappan Phase Cemetery (see Figure 13.18).

9

Urban Palaeoethnobotany at Harappa

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A broad range of the questions that can be asked of macrobotanical plant remains from an urban site are highlighted, using the site of Harappa as an example. The topics addressed include the uses of domesticated and wild plants, the nature of agricultural and cooking technologies, types of fodder and fuel, and the use of plant products in manufacturing processes. The necessity of integrating palaeoethnobotanical information with archaeological contextual data, including associated artifacts, is stressed.

Beyond the more usual 'village'-oriented agricultural topics, there is an additional set of questions that can be addressed with macrobotanical remains from an urban site like Harappa, in the same way that there are additional archaeological questions to be asked of urban sites than of smaller rural sites (Figure 9.1). This paper highlights a broad range of the types of questions that *can* be asked of macrobotanical remains, particularly as applied to urban sites.[1]

Questions

(1) What crops were important? The material from Harappa fills a crucial gap in our database from South Asia. This is the first systematically collected, large sample of plant remains from any of the sites in the Indus Valley proper and can be used to test many of the current conjectures about Harappan agriculture. There are some expectations about the probable suite of plants used at Harappa based on previous work, mostly fortuitous finds (Vats 1940). Wheat (primarily forms of *Triticum aestivum*), barley (*Hordeum vulgare*), and a variety of legumes (*Lens, Pisum, Cicer, Vicia*) were probably the major food crops. However, the *range* of crops grown is still unknown for Harappa and for the Indus Valley itself. The status of possibly major crops is uncertain; examples include cotton (*Gossypium* sp.), rice (*Oryza sativa*), the various millets (*Eleusine coracana* ssp. *coracana, Panicum miliaceum, Pennisetum typhoides, Setaria italica, Sorghum bicolor* ssp. *bicolor*, etc.), mustard (*Brassica* sp.), sesame (*Sesamum indicum*), linseed/flax (*Linum usitatissimum*), grape (*Vitis vinifera*), and date (*Phoenix dactylifera*).

Determining the presence and abundance of these crops through the archaeobotanical remains is necessary to support or disprove various interpretations of Harappan agriculture. In particular, the seasons of agricultural production have been debated for the Harappan period (one *vs.* two crops per year). The number of cultivation seasons is important for discussions about labor intensity, use of irrigation canals, and so forth (Fentress 1985; Ratnagar 1986). Furthermore, plant remains provide information about contacts with other areas, such as the introduction of the 'African millets' to South Asia (Possehl 1986).

(2) What wild plants were important? The use of collected wild plants by the Harappans is almost completely unknown. While the majority of plant staples were no doubt domesticates, the extent to which wild plants were important in the diet could be

Questions for Urban Palaeoethnobotany

1. Crops
   - Agricultural Systems
   - Contacts with Other Regions
2. Collected Wild Plants
   - Food
   - Building materials, crafts
   - Environment (with caution!)
3. Agricultural Technology
   - Cultivation Methods
   - Processing Methods
4. Cooking Technology
   - Domestic
   - Commercial
5. Fodder
6. Dietary Differences
   - Wealth
   - Ethnicity
7. Fuel
   - Domestic
   - Manufacturing
8. Manufacturing
   - Brewing, Wine-making
   - Oils
   - Cotton Cloth
   - Faience, Metal

Figure 9.1: Questions for urban palaeoethnobotany.

Basic Crop Processing Stages

Harvesting

↓

Threshing
(to free grain from chaff and straw)

↓

Winnowing
(to remove light chaff and straw)

↓

Separation of grain & contaminants
(via various sieving, shaking/rocking processes)

Figure 9.2: Basic crop processing stages

significant; for example, a ubiquitous find at Harappa is the fruit *jujube* (apparently undomesticated *Zizyphus* sp.). A variety of woods were necessary for use in construction, crafts, and fuel (Chowdhary and Ghosh 1951; Vats 1940), and impressions of reeds used for building materials and matting are also ubiquitous.

These collected remains can reflect the resources available in the surrounding landscape and, coupled with other information about the environment (from sediments, geomorphology, pollen), can contribute to environmental reconstruction, as Thiébault has done for the Kachi Plain (Thiébault 1988). For example, the quantity, quality, and diversity of wood charcoal in some Harappan deposits is quite surprising, in that there is far more charcoal and far less dung than I expected. Due to the preliminary state of my analysis, however, it is not yet clear whether this abundance of charcoal represents environmental conditions or a selective choice of wood *vs.* dung for certain purposes (see below).

(3) What was the nature of Harappan agricultural technology? In discussions of technologies and apprenticeships, archaeologists often overlook the fact that farming too is a craft, involving specialized knowledge passed on through 'apprenticeship' and a variety of technologies. Given the constantly changing hydrology of the Indus and its tributaries, the Harappans must have been especially flexible and innovative farmers, both technologically and in terms of their social systems. An example of the latter might be social institutions permitting rapid reallotment of land, such as common land ownership by groups, in order to deal with the constant shifts in the rivers' courses.

Determining the nature of Harappan agricultural technology—the first stage in understanding agricultural systems—is directly approachable through the macrobotanical remains. This can be achieved through an assemblage-focused approach, concerned with classes and numbers of remains in addition to the identification of particular species.[2] The correlation of archaeological plant assemblages to particular plant processing stages (e.g., threshing, winnowing, sieving) is an especially important part of this work. The basic methodology employed rests on the premise that the *by-products of various stages of plant processing are distinguishable on the basis of their composition* (Figure 9.2). In other words, if the by-products of plant processing stages are composed of a unique combination of plant parts, such as stems, glumes, awns, grain (prime or tail), and weed seeds of various size and shape classes, then specific combinations of plant parts are indicative of specific processing stages (Dennell 1972, 1974, 1976; Hillman 1973, 1981, 1984; Jones 1983, 1984, 1987; see also Hastorf 1988).

Discerning processing stages is very important for two different classes of archaeological questions about

agricultural technology: (a) methods of crop cultivation, and (b) methods of crop processing. The major application of Old World plant remains to reconstructions of ancient agricultural technology has been Dennell's, Hillman's, and Jones's work on distinguishing different agricultural processing stages (references above). Archaeological recognition of these processing stages allows palaeoethnobotanists to account for the distorting influence of processing on the original harvested crop assemblage. This is an important step in using the archaeological botanical remains as information about ancient agricultural practices like irrigation, crop rotation, fallowing, double cropping, and seasonal irrigation.

Identification of the processing stages themselves is also possible; for example, an assemblage of by-products from threshing is characteristically different from an assemblage of by-products from sieving. (A good analogy would be the assemblages of flake types generated by different stages in the production of stone tools or beads.) While research on distinguishing *between* these crop processing stages has been extensive, hopefully variation *within* the processing stages themselves is also detectable, such as the use of sieving *vs.* some other separation technique. A necessary but weak assumption made by both Hillman and Jones is that "crop processing is one of those activities which can only be achieved practically in a limited number of ways given a traditional technology" (Jones 1983: 80), such that "[i]n the execution of any one agricultural operation ... there are relatively few efficient methods available to the non-mechanised farmer, whether in terms of the overall sequence of operations that can be applied or in terms of the execution of any one operation" (Hillman 1981: 126). For instance, an example given by both Jones and Hillman is that removing small contaminants without the use of sieves would be "prohibitively time-consuming" (Jones 1983: 81, cf. Hillman 1981: 155-156).

In both South Asia and Australia, however, various shaking/rocking techniques rather than sieving processes are used to clean seeds. The general methodology used by Hillman and Jones is currently being applied to ethnoarchaeological investigations of millet processing in South Asia by Reddy (Ph.D. dissertation in preparation and Chapter 10 in this volume). If the shaking/rocking assemblages being studied by Reddy are statistically different from sieving assemblages reported by Jones (Jones 1983, 1987), the ability of this methodology to directly test the utility of *analogical* plant processing models makes it a very powerful archaeological tool.

The range of questions about processing technologies used by the Harappans is particularly broad, given their geographical position at the 'crossroads' between major world regions. Were they using 'Western Asian' processing technologies or 'South and Southeast Asian' processing technologies? Does this change over time? Or are different techniques used for different crops—sieving for *Triticum* and *Hordeum*, shaking/rocking for small round grains like millets? Could a processing technology that favored the recovery of small rounder grains be the impetus behind the selection for sphaerococcoids rather than the more usual environmental explanations?

In addition, changes in processing techniques and technology are a clue to the changing use of particular plants. Given the addition of new crops over time in this region, it will be important to determine if new processing technologies were adopted with new crops, or if the old techniques were retained. The Indus region will thus provide valuable data to test the hypothesis that new crops are more quickly adopted if they are suited to familiar technologies (D.R. Harris, personal communication).

(4) What were Harappan cooking technologies and how did they change over time? As with alterations in agricultural technologies, changes in cooking technologies are often linked to changes in the plants being used. Like other technologies, food processing technologies result in specific patterns of artifact use and refuse scatter, patterns which archaeologists must learn to recover and interpret. Unfortunately, food processing technologies are particularly difficult to recover, as they largely involve perishable items. Information is thus often limited to modern analogies, although chemical residue analysis, microwear patterns on stone tools, and shapes and placement of ceramics and grinding stones offer essential hints. Faunal analysis has taken this farther with the study of cut marks on bone, but the plant remains themselves have also been used to demonstrate technologies, such as the production of beer (Hillman 1981) and the processing of *saguaro* fruit (Miksicek 1987).

Through the careful integration of the plant information with other artifactual information, it is possible to identify changes in cooking technologies. A good example of the use of such integration comes from the site of Pirak, Pakistan, where Jarrige (1985) has correlated the adoption of rice cultivation to changes in the pottery assemblage, specifically to cooking vessels.

(5) What types of animal fodder were used at urban sites and how does this affect interpretations of human plant use? Palaeoethnobotanists have been concerned about the presence of seeds from dung in their samples, for fear of confusing assemblage interpretations (Miller and Smart 1984). Recently, however, they have realized the incredible information available about fodder from dung used as fuel (Charles 1989; Reddy 1991, Chapter 10 in this volume). Perhaps the

most important topics involving fodder concern the degree to which animals are integrated into the subsistence economy. The ability to determine what animals were being fed is a tremendous advantage in discussions about the growing of crops specifically for fodder or about free-range grazing *vs.* penned livestock. The use of complementary techniques to reconstruct animal diet strengthens such discussions, such as Reddy's combined use of bone chemistry and palaeoethnobotany (Reddy, Ph.D. dissertation in preparation and Chapter 10 in this volume).

(6) In what ways can plant remains provide information about wealth and ethnicity? In terms of dietary differences, the localization of certain types of foods in certain areas of a city, including the presence of 'exotics' and special fruits, has been applied to remains from medieval Amsterdam (Paap 1984). This methodology has greater resolution with historic sites, where prestige food items are known. However, it might be applied cautiously at Harappa in looking for differences between domestic refuse in different parts of the site. Wealth is also something to consider when assessing wood *vs.* dung fires; is one seeing not simply environmental differences, but a situation complicated by individuals with differential access to resources or by 'ethnic' groups with different views about acceptable cooking fuels? Plant remains, in conjunction with other artifacts, provide an additional line of evidence for such issues.

(7) How does fuel use relate to pyrotechnology? The use of wood *vs.* the use of dung as fuel re-occurs in this paper: as an additional line of evidence about the environment; in investigations of fodder type; and as a reflection of differential resource access ('wealth'). Type of fuel is also of major importance in many high-temperature pyrotechnologies, the best-known examples being ceramics and metal-working. The type of charcoal or the presence/absence and type of dung from kiln firings may provide valuable information about firing conditions for these crafts, and should be important aspects of theoretical and experimental reconstructions of ancient technologies.

(8) What can macrobotanical remains tell us about different craft activities? The information available from plant remains about a variety of manufacturing processes has been vastly under-utilized. Together with associated artifacts, plant remains can be used to identify the presence of a variety of manufacturing procedures: brewing; wine-making; the production of a variety of plant seed-based oils (sesame, mustard, cotton); stages in cotton cloth production (including dyeing); and even faience and metal production. All of this information forms an essential data base for conjecture about exchange in plant products and their 'commercial' importance.

Conclusion

Due to the wide range of applications for archaeological macrobotanical remains, large samples must be collected from as many different contexts as possible. In order to find the rare sample containing dumped fuel from a kiln, or soda/silica ash from faience manufacturing, or dung remains providing information about fodder, or remains from specialized food processing like fermentation, it is necessary to examine large numbers of samples of mixed domestic rubbish. This is why palaeoethnobotanical analysis is so time-consuming and thus expensive. To maximize scarce archaeological funds, therefore, sampling and recovery procedures must be evaluated and customized for each site, taking into account the economic resources, available labor, site size and preservation, and conditions of excavation.

Finally, *interpretation* of plant assemblages requires knowledge of their archaeological *context* and the nature of associated artifacts. As David Clarke put it:

> It has slowly emerged that there is archaeological information in the spatial *relationships* between things as well as in *things* in themselves. Spatial relationships are of course only one kind of relationship for archaeologists to investigate and the current interest in spatial relationships is thus merely part of the current ideological shift from the study of things (artefacts) to the study of the relationships between things (variability, covariation, correlation, association, change and process) (Clarke 1977, reprinted in Clarke 1979: 457; emphasis as original).

Thus, the excavation and recording techniques employed will probably be far more important for interpretations about the role of plants in ancient societies than new laboratory techniques. For example, it is often difficult to differentiate a *tandoor/tanoor* (bread oven) from a pit used for roasting and other kinds of cooking without careful excavation, plotting, and section drawing. Careful microstratigraphic excavations can help to discern what is fill, what is collapsed roof, and what are abandoned kiln contents—all important pieces of information when sampling for *assemblages* of small items like seeds. The major challenge for palaeoethnobotany at present is the ability of excavator and plant analyst to share such spatial,

relational information. The high level of communication between the various members of the Harappa team has encouraged such integration; it is a pleasure to work on such an *inter*disciplinary project.

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Notes

[1] 'Macrobotanical' refers to seeds, charcoal, and other plant parts visible under a low-power microscope.
[2] See Miksicek (1987) for an excellent overall review, Hastorf and Popper (1988) for an important discussion of analyses and a range of recent examples, and Pearsall (1989) and Grieg (1989) as general handbooks of palaeoethnobotany.

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Cover art: Bowl on Stand H88-1002/192-17 associated with Burial 194a
in Harappan Phase Cemetery (see Figure 13.18).

10

Complementary Approaches to Late Harappan Subsistence: An Example from Oriyo Timbo

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Understanding the interplay between subsistence systems and settlement patterns is crucial for interpretation of past economies and culture change. The Late Harappan (1900-1700 BC) in Gujarat, India, witnessed a significant increase in the number of settlements in the arid regions. This increase has been ascribed to shifts in land use patterns resulting from an increased emphasis on pastoral husbandry and the adoption of drought resistant summer crops, i.e., millets. This issue will be addressed using data from archaeobotanical and ethnographic studies complemented by carbon isotope analysis of cattle bones from the Late Harappan site of Oriyo Timbo, Gujarat.

Southeast of the site of Harappa, the geographical region comprising the modern Indian state of Gujarat is the southernmost extension of the Harappan cultural tradition known to date. The Harappan of Gujarat has a distinct regional expression, and excavations at a number of sites have revealed that a long history of Harappan presence can be defined in this region (Possehl and Raval 1989). Although on the periphery of the Harappan core area, Gujarat stands as a important region for the further understanding of the Harappan cultural sphere of interaction.

Gujarat appears to have been settled during the urban Harappan phase of the Indus Valley Tradition by populations from the greater Indus region. Radiocarbon determinations from the sites of Lothal and Surkotada suggest a date of ca. 2400-2300 BC for this settlement. Possehl notes that Rojdi, and many other sites in Gujarat, represent a specific—and newly defined—regional expression of the Harappan urban phase, which clearly is a part of the larger Harappan cultural entity (Possehl and Raval 1989).

While the Harappan is characterized by urban centralization, craft specialization, and diversified subsistence economy, the Late Harappan is defined by the retention of specific Harappan attributes but in a context of de-urbanization, expansion of settlements into new regions, changes in subsistence regimes, and the development of new regional traditions.

Understanding the interplay between subsistence systems and settlement patterns, as seen in the Greater Indus Valley, is crucial for interpreting past economies and culture change in general. In comparison to the Harappan (2500–2000 BC), the Late Harappan (1900–1700 BC) in Gujarat witnessed a significant increase in the number of settlements in the arid regions (Bhan 1989). This increase was accompanied by a decrease in average site size. These trends have been ascribed to a shift in land use patterns resulting from an increased emphasis on pastoral animal husbandry (Rissman 1985; Bhan 1989) and to the adoption of summer crops, i.e., millets (Possehl 1986). (In this paper, summer drought resistant crops will be generically referred to as 'millets'.) The cultivation of millets, which are summer and drought resistant crops, would have facilitated expansion into the arid regions of Gujarat. Very little is known about the impact of these cultigens on the Harappan subsistence economy. Here, the hypothesis is that they supplemented rather than replaced earlier subsistence

practices, and they came to play an important role in the increased emphasis on animal husbandry and specialized food production systems in the Late Harappan.

Most of the suggestions regarding the Harappan subsistence regime are to a great extent hypothetical, but the use of multiple lines of evidence has considerable potential to contribute to the understanding of the processes and character of Harappan subsistence systems. Using the complementary methods of archaeobotanical analysis, ethnographic crop processing studies, and carbon isotope analysis of cattle remains, I am investigating the Late Harappan subsistence economy. My ethnographic research centers in the States of Gujarat and Andhra Pradesh, while the archaeobotanical data and the cattle bones for the carbon isotope analysis are from the Late Harappan site of Oriyo Timbo.

The Example of Oriyo Timbo

The second season of field research at the post-urban site of Oriyo Timbo, Gujarat, took place in 1989-90, and was a collaborative undertaking between the Gujarat State Department of Archaeology and the University Museum of the University of Pennsylvania. Oriyo Timbo was first excavated in 1981-82 by a team from the State of Gujarat and the University of Pennsylvania (Rissman and Chitalwala 1990).

The first season of excavations at the site revealed Oriyo Timbo to be a seasonally occupied camp inhabited during the Lustrous Red Ware period by pastoralists who may have undertaken a bit of cultivation (Rissman and Chitalwala 1990, Possehl 1990). Below this proto-historic camp was a distinct microlithic occupation with microlithics and a small amount of pottery. The relationship between these two occupations remains unclear and speculative. The second season of excavations were aimed at further investigating this relationship and at defining the Lustrous Red Ware settlement.

The 1989-90 field season at Oriyo Timbo entailed the excavation of six 5 × 5m grid units immediately south of the 'Western Operation' area of the 1981-82 excavations (see Rissman and Chitalwala 1990: Figure 1). Twelve stratigraphic layers of sediments were identified in the course of the excavation, but they comprised no more than three distinguishable occupations (Possehl 1990). The site is interpreted as having three distinct Lustrous Red Ware occupations, each associated with a series of compacted surfaces with features and concentrations of artifacts resting upon them. Between these are layers of less compacted sediment representing general fill. The first occupation is represented by stratum 6, with stratum 7 being the natural sediment; the second occupation is associated with stratum 5 and the final occupation is stratum 3. The extent and duration of these occupations cannot be determined at this time. Stratum 4, a softer compacted fill, is distinct from the compacted series of layers in stratum 5 that have high ceramic densities and also features associated with food preparation (i.e., chulas, a tandoor, ash pits).

Methods of Archaeobotanical Recovery

The objectives of the archaeobotanical recovery and analysis are essentially twofold: to gain an understanding of the nature of the subsistence economy and to elucidate spatial and temporal variations in the plant materials at the site. An ideally representative archaeobotanical assemblage would include all the plant species actually in use at a site, along with some indication of the relative importance of each species in antiquity. Adequate sampling from a sufficiently large number of contexts is imperative to provide such an assemblage. Therefore, systematic sampling was employed with a minimum volume floated of 10 liters per sample unless there was a defined feature. Contexts sampled include hearths, ovens, compact living floors, dumps, pits, and fill areas. Such sampling methods are necessary for the successful identification of macro-assemblages and localized associations related to different economic activities such as plant processing, consumption, and disposal. (For further details on recovery methods, see Reddy 1991.)

Archaeobotanical Analyses

The last (1989–90) season at Oriyo Timbo, resulted in the retrieval of archaeobotanical remains from 247 samples comprising over 3000 liters of unscreened dirt from six trenches. For this study only carbonized seeds were analyzed, with non-carbonized seeds being excluded due to the probability of they being modern intrusives.

To summarize the results, it is appropriate to say that there is strong evidence for the use of summer crops. These include crop plants such as *Eleusine, Panicum, Setaria,* and a variety of legumes and weeds. The plant remains occur in varying frequencies in all the trenches, but high concentrations occur in only three of the six trenches.

Stratigraphically there is patterned variation in the frequencies of carbonized seeds recovered, with strata 5 and 6 having higher frequencies of seeds than stratum 4 (Figure 10.1). This correlates well with the stratigraphic sequence of occupation floors and

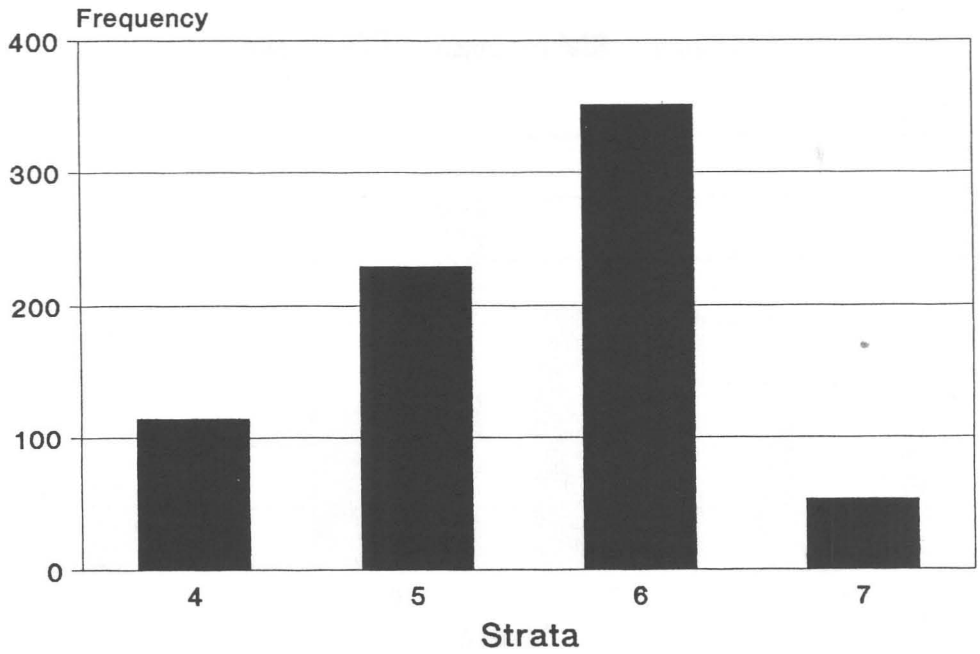

Figure 10.1: Oriyo Timbo (1989-90): Total identified carbonized seeds by strata.

features associated with food preparation in strata 5 and 6, while stratum 4 is primarily occupation fill.

In the analyzed samples, 36% are 'millets' and 31% are weeds (Figure 10.2). Among the millets, *Eleusine* comprises 20% of the total seed assemblage, followed by *Setaria* (8%), *Panicum* (6%), and *Pennisetum* (2%). Among the weeds, *Trianthema/Mollugo* (28%) comprises the highest percentage. Legumes constitute 5% of the total assemblage. Although the percentage of millets in relationship to other plants, such as the weeds and legumes, varies between trenches, the relative frequency of the different genera of millets is similar in all the trenches. (For a detailed report on the findings see Reddy 1991.)

At Oriyo Timbo the carbonized plant remains appear to be differentially preserved based on context. The distribution of carbonized seeds at the site seems not to be concentrated in any functional loci, such as hearths or ovens. In fact, the samples from these contexts show a relatively low density of seeds when compared to the general fill sediments from the different trenches (Figure 10.3). Contexts with the highest probability of fire (that is high temperatures) such as the hearth samples and the tandoor or oven fill contents and the oven wall, have the lowest frequency of carbonized seeds. Whether this correlation is a result of a lack of preservation due to the high temperatures in these contexts or a result of no seeds being associated or incorporated into these contexts will be explored through ethnographic modeling.

Whether these millets were cultivated at the site by the occupants or brought onto the site from elsewhere is still an unresolved question. However, given the relatively rich assemblage, the lack of storage heaps, and the high number of weeds associated with the summer crops, it is probable that they were cultivated by the site occupants. A thorough ethnographic study of summer crop processing geared to studying the patterns in product and by-product compositions will enable me to address this issue more effectively.

A second major question is the economic importance of the millets and the economic role of crop cultivation as compared to animal husbandry. Understanding of this issue should yield insight into the full character of this Late Harappan site and the regional expression of the late Harappan subsistence economy.

Archaeobotanical data alone is not adequate to address these questions; it has to be supplemented by other robust data sets. My approach is to integrate archaeobotanical analysis with ethnographic studies of crop processing and carbon isotope analysis of cattle bone from archaeological sites. To understand Oriyo Timbo, which has been interpreted as a pastoral settlement, one needs to consider the importance of crop cultivation, the role of cultivated crops for food and fodder, and the relative economic

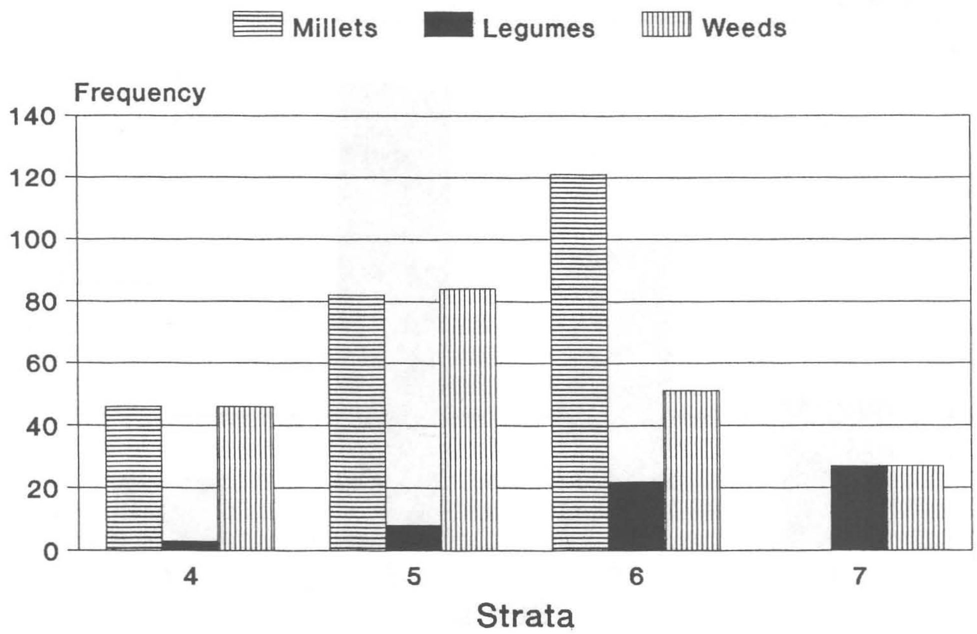

Figure 10.2: Oriyo Timbo (1989-90): Frequency ratios of carbonized millets, legumes, and weeds in different strata.

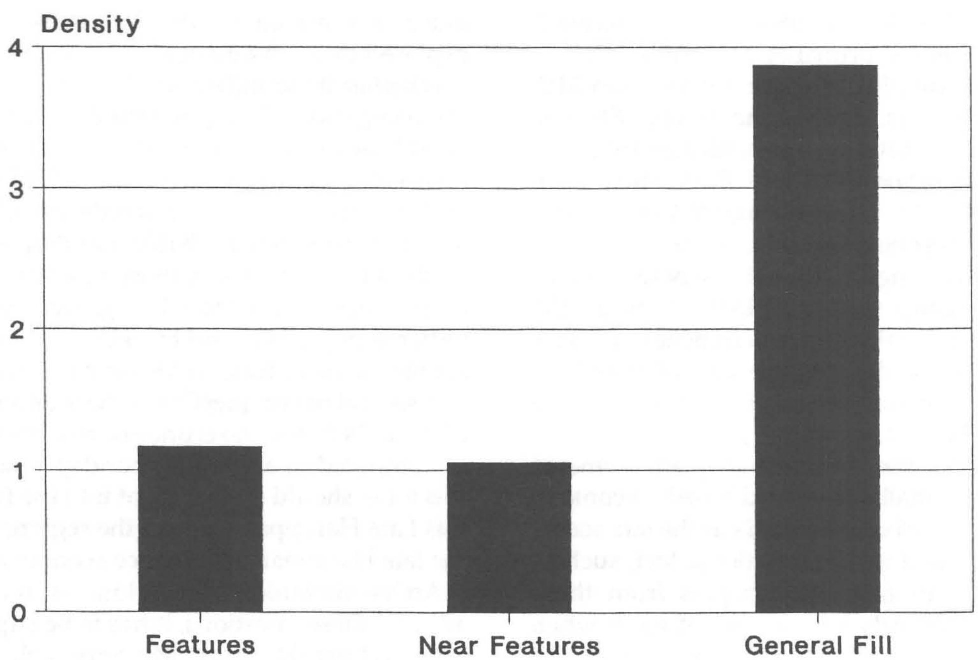

Figure 10.3: Oriyo Timbo (1989-90): Densities of seeds/10 liters.

dependence on cattle by the occupants. For a comprehensive investigation of these issues, the quantitative results from the three analytical methods I have selected need to be evaluated and thoroughly integrated.

Ethnographic Studies

The underlying objective of the ethnographic study is to determine whether the archaeobotanical samples recovered at Oriyo Timbo are representative of assemblages related to different crop processing stages and/or representative of assemblages which are distinctive for their use as human food or as animal fodder. The assumption behind this study is that each step of crop husbandry and grain processing has a measurable effect on the composition of crop products and by-products (Figure 10.4). These effects can be studied and 'cause and effect' models can be built and applied to archaeological samples, thus enabling inferences to be made on the archaeological use of specific crops.

My ethnographic research to date has confirmed that the wheat/barley/pulse models of crop processing developed by Hillman (1981, 1984) and Jones (1983, 1984, 1987) are not applicable for millet crops. This is because the harvesting methods are very different due to differences in plant morphology. Millet crops like *Sorghum*, *Pennisetum*, and *Eleusine* are harvested by cutting off the inflorescence heads only, which is different from the way wheat and barley are harvested. This initial variation in processing has a measurable effect on the composition of crop products and by-products (Figure 10.5).

The second observation from my research is that plant parts such as rachis remains, used in wheat and barley crop processing models, do not appear to be as suitable for distinguishing the different stages of millet processing. These plant parts in millets are fragile and not likely to survive in the archaeological record. It is possible, however, that other plant parts, such as spikelets of particular sizes and composition, may be more indicative of processing stages. The crop processing model I am developing for millet crops also relies on the relative variation in weeds for isolating the variables which define the different stages and uses. It is crucial to note, however, that the presence of weeds is quite often heavily dependent on the nature of cultivation. Alluvial flood plain cultivation (discussed below) could differ significantly from valley monsoonal cultivation in terms of composition of the crops fields due to non-human ecological variables.

In Andhra Pradesh, when millets are primarily grown for animal fodder, they are cultivated on flood banks of rivers. In such instances, due to the comparatively 'sterile' condition of the seasonally flood-deposited silts and clays on these river banks, the crop is poor but weeds are absent or very rare in the fields. This affects the forage quality, nutritive value and, most crucially, the composition of the crop processing by-products. Essentially, with such cultivation, the relative number of weeds in the products or by-products consumed by animals differs significantly from the number of weeds in the products and by-products of millet processing from plain and valley cultivation. This critical distinction is invaluable for interpretation of archaeobotanical assemblages from similar environs.

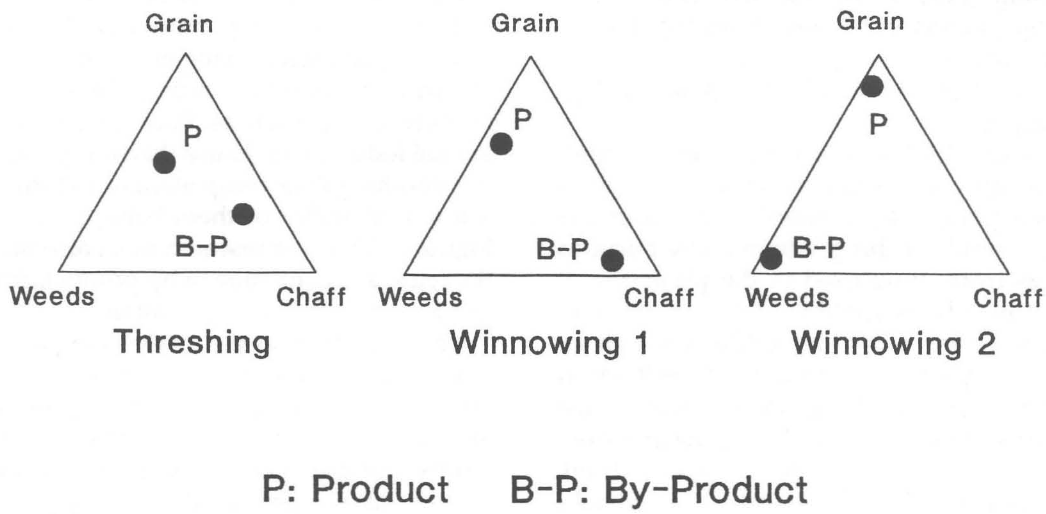

Figure 10.4: Hypothesized ethnographic crop processing product and by-product compositions.

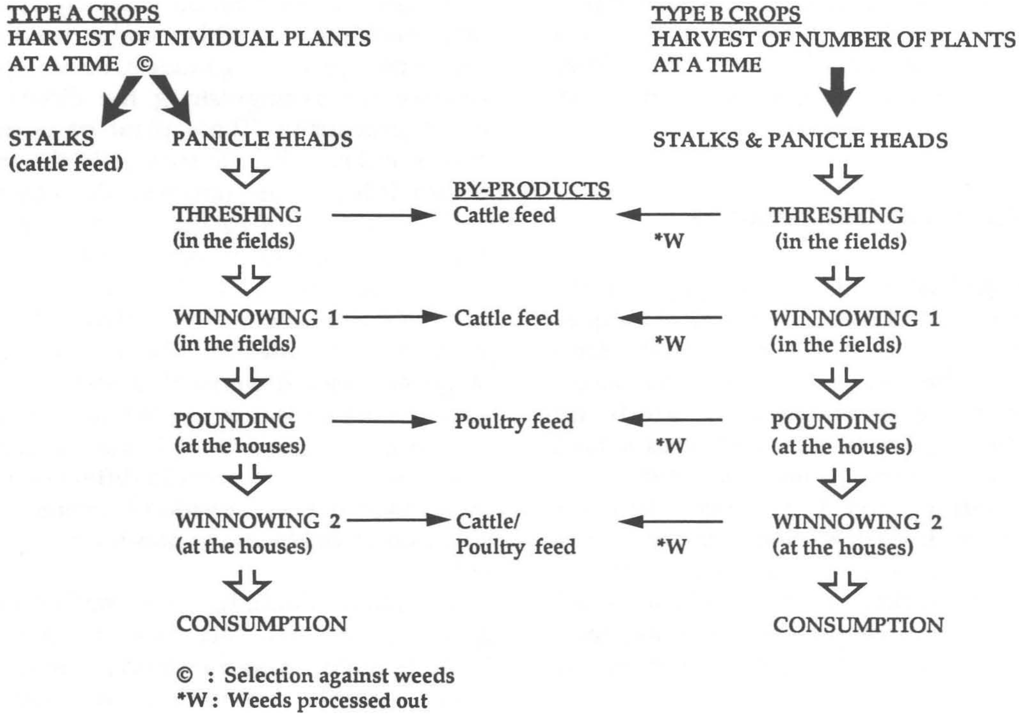

Figure 10.5: A preliminary predictive model for millet crop processing stages; TYPE A CROPS include *Sorghum bicolor*, *Pennisetum typhoides*, and *Eleucine coracana*; TYPE B CROPS include *Panicum miliare* and *Setaria italica*.

Of crucial importance during the ethnographic studies is defining contextual situations that could be archaeologically preserved. Which activities and contexts are most likely to produce archaeologically relevant materials? These would include, for example, the cleaning of grain before consumption, the location of this cleaning (particularly the distance from a hearth), and the discard of cleanings. Similarly, knowledge of the sediment composition of the living floors and how they are formed is invaluable for archaeological interpretation.

Miller and Smart (1984) have suggested that a significant percentage of archaeobotanical materials retrieved from living floors, hearths, and ovens is preserved as a result of dung intentionally burnt as fuel as well as from dung used in the plastering of floors. Thus it may be possible to identify the use of millet residues versus grains as fodder through an intensive ethnographic study of their compositions. It is possible, however, that the grains included in the dung could come from elsewhere (i.e., inclusions from where and when the dung was dropped, dried, packed, etc.) rather than directly from the animal's digestive system. These variables can be controlled and explained only after a thorough understanding of the source of seeds in archaeological sediments. Crop by-products are also often used as fuel in the Third World, but millet by-products rank quite low as attractive fuels when compared to wheat, barley, and sugarcane crop by-products (Barnard and Kristoferson 1985:79).

The shortcoming of such an ethnographic approach is that rarely do crop processing by-products from threshing and winnowing occur in the archaeological record as individual entities; often they are units of another entity such as floor plaster, animal dung, animal fodder, fuel, house thatching, and so on. While the threshing floor components are distinctive, there is a low probability of them being preserved archaeologically. Thus the research must also take account of the reuse and conflation of by-products from a number of stages and their interpretation.

Upon completing the analysis of the ethnographic fieldwork, the resulting models will be applied to the archaeological samples/contexts from Oriyo Timbo, allowing for a more robust interpretation of their nature and use in antiquity. There remains, however, the popularly perceived shortcoming of all such ethnoarchaeological studies, namely, the danger of direct analogy, and one has to be cautious of this when

interpreting archaeological context through ethnographic modeling.

Carbon Isotope Analysis

I have chosen Carbon Isotope Analysis to try to identify the relative importance of millets as animal fodder at Oriyo Timbo. If millets were used as a major source of fodder, then the resulting high proportion in the animal diet of plants with C_4 photosynthetic pathways should be reflected in a relatively heavy carbon isotope signature ($\delta^{13}C$) of the animal bone collagen.[1] Ratios of the two stable isotopes of carbon, Carbon 13 (^{13}C) and Carbon 12 (^{12}C) in animal bone collagen have been used to determine the relative contribution of C_4 plants (such as maize and millets) versus C_3 plants (such as wheat and barley) to the diet of the consumer (DeNiro and Epstein 1978; van der Merwe 1982). Carbon isotope analysis can be employed here to determine the extent of millet use during the Late Harappan, because millets were the primary C_4 plants of economic importance in this area.

In such an investigation, however, one needs to consider the seasonality of fodder availability, mixed feeding on C_3 and C_4 plants, and the cultivation of millets both as food for humans and fodder for animals. Thus ethnographic studies are necessary to permit development of models for interpretation. The development of these models is a topic too large to discuss in this paper, but briefly, the chemistry of the animal bone collagen is ultimately dependent on a number of variables including nature of local sediments and vegetation, herding characteristics, nutritive value of forage, forage availability, forage selection, and potential of fodder intake (Figure 10.6). For archaeological application, only some of these variables can be observed and quantified through ethnographic studies. These include seasonality of fodder, forage nutritive quality, and selection by animal and herder.

My preliminary ethnographic observations of pastoralist and farmers in Gujarat during 1989–90 have shown that there is seasonality in the availability and consumption of fodder by cattle and goats. Often wild fodders such as *Cressa cretica* (commonly known as *bokhna*) are preferred over millets and other crops or their residues. *Bokhna* is readily available in winter and enhances milk production because its high protein content induces lactation. It is only used when fresh, and when available it is given primary preference. But as *bokhna* cannot be stored as dry fodder, it is used exclusively when available. Millets and other wild fodders are used during other seasons.

PLANT - ANIMAL INTERRACTION COMPLEX
a. Seasonality (Availability)
b. Forage Quality (Nutritive Value)
c. Herd Effects (Grazing, Browsing, Free Range)
d. Potential Intake (Age, Size, Condition, Type)

↓

ANIMAL FEEDING COMPLEX
a. Level of Intake
b. Digestion and Utilization of Nutrients
c. Selection by Animal & Herder

↓

FINAL ANIMAL PRODUCT
a. Dairy and Meat
b. Bone Composition

Figure 10.6: An animal feeding model.

Carbon isotope analysis cannot recognize such seasonality in fodder consumption, as bone collagen has a slow turnover rate. But what is of primary concern for questions related to the economic importance of millets to the occupants of Oriyo Timbo is the relative proportion of millets in the animal diet rather than the exact amount. Similar studies can be made on human bones, although none are currently available to me from Gujarat to conduct such studies.

A relatively heavy $\delta^{13}C$ signature from the cattle bones would imply that C_4 plants were consumed in greater proportions and that millets were a major contribution to the animal's diet. Modern samples of wild fodders from the area produce the lighter $\delta^{13}C$ values of C_3 plants so wild fodders would not confuse this issue. However one question would remain—whether millet grain or millet by-product was being fed as fodder. This distinction is significant because the use of millet grain for animal fodder would indicate that the crops were primarily grown for animals, whereas using only the millet residues for fodder implies that the crops were grown for both human and animal consumption. The difference has a significant effect on the interpretation of the subsistence economy. Although it may seem counterproductive to cultivate millets only for animal fodder, ethnographic data from traditional, non-mechanized farmers and pastoralists show that, very often, quick maturing millets are

cultivated solely for animals as (1) insurance for lean periods, (2) a means for promoting lactation, and (3) a form of opportunistic cultivation.

The implications of a lighter $\delta^{13}C$ (C_3) signature are less straight forward but could have far reaching implications, particularly with respect to the 'pastoral' character of the site and the importance of cattle in the subsistence economy of Oriyo Timbo. If the animals are feeding on the wild fodder, then questions arise relating to whether a sizable herd really could be maintained in the environs around Oriyo. This is particularly problematic during the four month lean dry period every year. Therefore would the herd have to be taken to other locales during this part of the year?

Although carbon isotope analysis has its shortcomings regarding the detection of seasonality and other related processes, the signatures will provide insights into the long term proportional feeding of C_3 or C_4 plants.

Conclusion

To conclude, the Late Harappan phenomenon in Gujarat, although subject to considerable research, is yet to be fully defined. The region stands as an important component of the Harappan cultural tradition. Changes in settlement patterns and subsistence strategies during this period have been linked but the nature of and reason for this correlation are not yet understood.

With respect to the study of Harappan subsistence economy in Gujarat, the exact proportion of millets in animal diets is not as critical as relative long term changes in the dependence on different fodders, particularly millets versus other fodders. An increased emphasis on millets as fodder, or concentration on fodder cultivation in general during the Late Harappan of Gujarat, may indicate the emergence of a specialized subsistence system, with pastoral animal husbandry as an important and critical variable, perhaps similar to present day Gujarat. Such a change in subsistence economies, entailing specialized food production and intensification, would have far reaching implications for our understanding of the Late Harappan of Gujarat.

In sum, the integrated results of this research should further clarify the subsistence economy at Oriyo Timbo and shed more light on the Late Harappan of Gujarat in general thereby furthering our understanding of the nature of Late Harappan subsistence—be it a pastoral, agricultural, or a mixed system.

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Note

[1] The use of 'heavier' to indicate a less negative $\delta^{13}C$ value (richer in ^{13}C) and 'lighter' to indicate a more negative $\delta^{13}C$ value (less rich in ^{13}C) follows a practice noted by O'Leary (1981:553).

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Cover art: Bowl on Stand H88-1002/192-17 associated with Burial 194a
in Harappan Phase Cemetery (see Figure 13.18).

11

Biological Adaptations and Affinities of Bronze Age Harappans

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Cranial and dental metric and non-metric data derived from human skeletal remains of the Harappan phase at Harappa are employed together with comparable data from South Asia and neighboring areas to address questions of biological adaptation and continuity. A progressive decline in dental health is demonstrated to have occurred within the Indus Valley from the neolithic to the urban phase of the Harappan Civilization. This accords well with expectations of the proximate effects of increasing reliance upon agriculture. Sexual differences in dental health and differences in tooth size between humans from South Asian sites of different periods can also be related to diet and food preparation techniques. As for the question of biological continuity within the Indus Valley, two discontinuities appear to exist. The first occurs between 6000 and 4500 BC and is reflected by the strong separation in dental non-metric characters between neolithic and chalcolithic burials at Mehrgarh. The second occurs at some point after 800 BC but before 200 BC. In the intervening period, while there is dental non-metric, craniometric, and cranial non-metric evidence for a degree of internal biological continuity, statistical evaluation of cranial data reveals clear indications of interaction with the West and specifically with the Iranian Plateau.

This paper seeks to employ biological data derived from human skeletal remains recovered from the Harappan phase cemetery ("Cemetery R37") at Harappa to address two current areas of discussion raised by analyses of non-skeletal remains. These areas are progressive agricultural intensification and biological continuity.

The first of these areas concerns biological adaptation. Perhaps the most significant adaptations faced by Bronze Age Harappans were those incurred through dietary changes wrought by increasing dependence on domesticated foodstuffs. Earlier workers consistently emphasized the agricultural economy of Harappan society. In fact some scholars, impressed by the worker's platforms and granaries found in the northern part of the site of Harappa (Mound F), developed elaborate interpretations of cultural development that hinged on forces of economic development (Childe 1950, 1957).

Archaeological evidence of increasing agricultural intensification within the Indus Valley has been well documented (Allchin and Allchin 1982; Fairservis 1975; Meadow 1989). The earliest evidence for settled agriculture in South Asia comes from aceramic and later neolithic levels at Mehrgarh (ca. 6000 BC), where impressions in mud-brick of six-row barley, einkorn, emmer, and durum-bread wheat were identified by Costantini (1984). In the chalcolithic period (ca. 4500 BC), barley continued to be used but was accompanied by a dramatic increase in wheat utilization. Costantini (1979, 1984, 1990), Jarrige (1985), and Meadow (1989) have interpreted archaeobotanical remains from the occupational sequence in the Kachi Plain (Mehrgarh-Nausharo-Pirak) as comprising an early (neolithic) barley/wheat subsistence base established by the mid-sixth millennium BC that came to be supplemented in the early 2nd millennium by use of other cultigens such as rice, millets, and sorghum.

Apart from this direct evidence of cultivated foodstuffs, many important technological developments relating to food storage and preparation are also evident from aceramic and chalcolithic levels at Mehrgarh. These include the development of utilitarian pottery, grindstones, composite microlithic

sickles, and grain storage structures (Jarrige 1981, 1985; Jarrige and Meadow 1980; Jarrige and Lechevallier 1979; Lechevallier and Quivron 1981, 1985; Lechevallier et al. 1982). Similarly, faunal remains demonstrate a shift from wild to domesticated varieties of cattle, goat, and sheep during the course of the neolithic period (Jarrige and Meadow 1980; Meadow 1982, 1984, 1987, 1989).

Evidence of increased dependence on agricultural foodstuffs is abundant from the Indus Civilization sites of Harappa, Kalibangan, and Mohenjo-daro (Allchin and Allchin 1982). Archaeological evidence indicates that two varieties of wheat, barley, field peas, sesame, and mustard were cultivated at these sites, while ploughed fields during pre-Harappan times at Kalibangan (Thapar 1973, 1975) suggest considerable antiquity for the contemporary practice of ploughing furrows at right angles to one another in order to accommodate two crops simultaneously. Although there is no conclusive evidence for the so-called "granaries" having been used to store grain, it is reasonable to assume that grain was an important staple during this period of prehistory (for discussion, see Fentress 1984). Harappan sites also present a well developed copper/bronze technology, which includes a variety of vessels and tools that may have been used in the treatment and preparation of cultivated foodstuffs (Allchin and Allchin 1982; Wheeler 1968).

Examination of faunal remains by Meadow (1987, 1989, Chapter 7 in this volume) and Belcher (Chapter 8 in this volume) suggests that the hunting of wild animals and fishing constituted important aspects of the Harappan subsistence strategy. These exploitation patterns are attested by the bones of a wide range of wild species recovered from Harappan sites and indicates a more intensive use of wild species during the Harappan period than at any time since the neolithic. These data suggest that, while the Harappan Civilization was no doubt an agriculturally-based society, non-agricultural foodstuffs nevertheless continued to play a vital role in the Harappan economic system. This continued utilization of non-domesticated foodstuffs may therefore be a factor that calls into question earlier models of the development of the Harappan Civilization which presumed an overwhelming reliance on intensive agricultural exploitation for increasing centralization, state formation, and intra- as well as inter-urban interdependence.

Assessment of tooth size and dental health provides insight into subsistence patterns and dietary change. Recent studies of dental afflictions by age, sex, and social status among contemporary African hunter-gatherer and horticultural groups have demonstrated that differences in subsistence activity patterns are accompanied by differences in dental pathology prevalence patterns (Walker and Hewlett 1990). In addition to these cultural factors, recent studies by Hildeboldt et al. (1988, 1989) demonstrate that the distinctive bio-geochemical features of localized geographic areas also influence dental disease prevalence. Together, these behavioral and geographic factors are responsible for the well-documented inter-populational differences in oral health that accompany changes in dietary behavior.

Although odontometric and dental pathology data are often employed in other areas of the world (Armelagos 1969; y'Edynak and Fleisch 1983; Frayer 1987, 1989; Greene 1972; Hodges 1987; Larsen 1984; Machiarelli 1989; Molnar and Molnar 1985; Powell 1988; Turner 1979), results of these studies are not consistent, and no comprehensive analysis of dental pathology among prehistoric populations of the Indian subcontinent yet exists. The data presented in this paper permit the first diachronic assessment of the consequences of dietary change on tooth size and dental health among prehistoric South Asians. Therefore, the significance of this new South Asian data is two-fold. First, these data may be used to identify biological responses to agricultural intensification shared by Harappans and other South Asians. Second, comparison of this South Asian data with data from other regions of the world allows detection of any unique or distinctive trends in pathology prevalence shared by South Asians commensurate with increased reliance upon domesticated foodstuffs (Lukacs 1991).

The second area addressed by this paper involves biological affinities. The questions addressed here are: Who were the Harappans? To whom do they share greatest biological affinities, and does the pattern of affinities possessed by Harappans indicate biological continuity or discontinuity within the Indus Valley throughout prehistory?

The rise and fall of the Harappan Civilization has been the topic of much research since the discovery of Harappa and Mohenjo-daro. Sir John Marshall, excavator of Mohenjo-daro, was an early proponent of indigenous development of the Harappan Civilization from pre-Harappan cultures within the Indus Valley (Marshall 1931). Later scholars believed the Harappan Civilization to be the product of "stimulus diffusion," or actual migration from the West (Gadd 1932; Gordon 1947, 1958; Heine-Geldern 1956; Mackay 1938; Piggott 1950; Wheeler 1968). Numerous correspondences in ceramic wares, seals, metal artifacts, beads, and other items of material culture have been cited as evidence of contact between the Indus Valley and Mesopotamia.

Further investigations within the Indus Valley, Afghanistan, and Iran since 1960 once again have led many scholars to support a model of indigenous development. Ghosh's (1965) argument for ceramic

continuity between "pre-Harappan" times and the "Mature" Harappan period was followed by the "Indigenous Place" and "Three Influences" theories of Dales (1965) and Fairservis (1975). Continued investigation of new sites and re-examination of previously excavated sites in the late 1960s and early 1970s brought additional support for indigenous development of the Harappan Civilization from pre-Harappan cultures within the Indus Valley (Allchin and Allchin 1968, 1982; Jarrige 1982; Jarrige and Lechevallier 1979; Jarrige and Meadow 1980; Mughal 1970, 1990).

However, excavations in Iran, Afghanistan, and western Pakistan have indicated to other workers (Beale 1973; Biscione 1983; Kohl 1978, 1979; Lamberg-Karlovsky 1972, 1978; Lamberg-Karlovsky and Tosi 1973; Santoni 1984; Tosi 1979) that prior to the rise of the Harappan Civilization, the Indus Valley was part of an "early urban interactive sphere" centered on the traders of the Iranian Plateau. Participation of the Harappan Civilization in this "interactive sphere" may have led to considerable extra-Indus Valley input and participation in the rise of the Harappan Civilization.

No less vexing than issues surrounding the rise of the Harappan Civilization, are questions concerning its demise. Tentatively dated to the period between 1900 BC (Dales 1973) and 1750 BC (Agrawal 1966; Allchin and Allchin 1968), the demise of the Harappan Civilization has been attributed to Aryan invaders (Childe 1957; Gordon 1958; Piggott 1950; Wheeler 1968), ecological changes (Dales 1966; Kennedy 1984a; Kenoyer 1988; Lambrick 1967; Misra 1984; Raikes 1964, 1965), and simple progressive degeneration (Fairservis 1975).

Archaeological attempts to resolve questions concerning the rise and subsequent fall of the Harappan Civilization have been plagued by problems in dating, inaccessibility of key research areas, and interpretations of ceramic and other artifactual assemblages. Recent excavations at the Harappan phase cemetery at Harappa allow a unique opportunity to examine these questions from the perspective of skeletal biology. Unlike ceramic styles, decorative motifs, and metallurgical technology, genetically controlled features of the teeth and skeleton cannot be transferred verbally or inherited by others not in actual contact with the reference population. Unfortunately, many previous analyses of skeletal remains in South Asia have been limited by an overt racial-typological approach to human biological variation, by employment of parameters that incorporate an unknown amount of environmental variation, or by questionable attempts to force these data into a model of localized continuity (Dutta 1972, 1975, 1983; Guha and Basu 1938; Gupta, Dutta and Basu 1962; Krogman and Sassman 1943; Kumar 1971, 1973; Sarkar 1954; Sewell and Guha 1931).

This study not only provides new biological evidence from the Harappan phase cemetery (R37) at Harappa, but simultaneously employs several multivariate statistical techniques based on three different types of biological variation (cranial metric, cranial non-metric, and dental non-metric). Employment of several statistical techniques offers the advantage of avoiding conclusions drawn from any one alone, as all contain their own inherent biases. Similarly, use of more than one type of biological variation allows a composite picture of affinities to be drawn from the entirety of variation available at this time. This approach helps to alleviate such problems of biological affinity analysis as directional selection and differential levels of sexual dimorphism.

Materials and Methods

The Harappan phase cemetery at Harappa is located to the south of Mound AB and was designated as "Cemetery R37" by Shastri in 1937-38 (see Possehl, Chapter 2 in this volume) (Figure 11.1). Subsequent excavations in the same general area by Wheeler (1947) and Mughal (1968) also resulted in the recovery of Harappan phase burials. Earlier in the 1920s and 1930s, Vats (1940) excavated in the area between Cemetery R37 and Mound AB and recovered two different types of burials referred to as Cemetery H Stratum II (lower or "earth" burials) and Stratum I (upper or "pot/jar" burials). Both of these burial types belong to the Late Harappan phase and are later than the burials in the Harappan phase cemetery (Cemetery R37).

Excavations by the University of California, Berkeley (UCB) Project have resulted in the recovery of more than 90 individuals from the Harappan phase cemetery (Table 11.1: hereafter termed "R37C"). This number compares favorably with the 106 reported by Dutta (1983) from previous excavations in the same general area (Table 11.1: hereafter termed "R37A"). Unfortunately many of these individuals are extremely fragmentary. When well-preserved individuals are used as the basis of comparison, 33 individuals were recovered in 1987 and 1988 and 34 individuals were recovered from previous excavations. Thus the UCB excavations have led to a doubling of the skeletal information available for the Harappan phase inhabitants of the site.

The R37C sample (from the UCB excavations) represents a young to middle-aged adult population, for few children and juveniles were recovered.

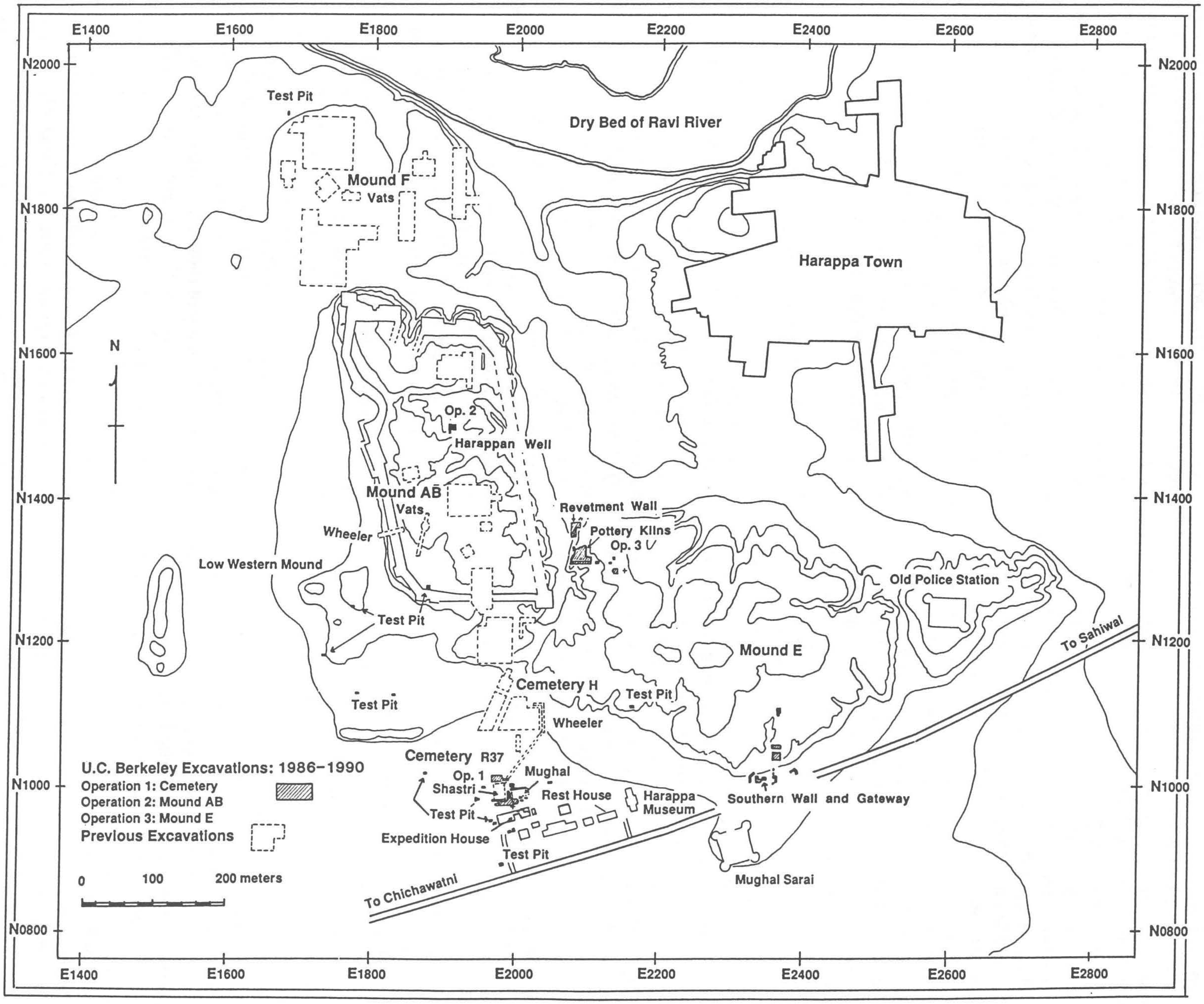

Figure 11.1 Location of the Harappan phase cemetery within the site of Harappa.

Similarly, the number of older adults recovered was also low (Table 11.2).

Dental remains obtained during the UCB excavations were examined by Lukacs. The dental sample was recovered from two different burial contexts: primary and secondary (Table 11.3). Primary context remains are composed of 16 undisturbed burials. Secondary contexts include incomplete skeletal remains displaced from their original context by erosion or by later intrusive interments. Dental remains recovered from disturbed contexts are defined as "secondary" if retained in jaw fragments. Loose teeth not in association with jaw remains are defined as "isolated." Dental remains from primary burials constitute nearly half of the entire sample (48.1%), while isolated remains account for only 15%. Males and females are equally represented, but nearly one-fourth of the sample is derived from individuals of unknown sex.

Analysis of tooth size involves measurement of tooth length and tooth breadth. In this report tooth length is defined as the mesiodistal (MD) diameter of

Table 11.1. Sex Distribution of the Harappan Phase Cemetery Samples

Sample	Males	Females	Unknown	Total
R37A	38	55	13	106
R37C	19	29	42	90
Total	57	84	55	196

Table 11.2. Age Distribution of the Harappan Phase R37C Sample

Category	Age Range	Number
Subadult	< 16 Years	15
Young Adult	17-34 Years	35
Middle-Aged Adult	35-55 Years	27
Older Adult	> 55 Years	13
Total		90

Table 11.3. Harappan Phase R37 Dental Sample by Burial Context and by Sex

Context

	Primary			Secondary			Isolated			Total		
	Max	Man	Total	Max	Man	Total	Max	Man	Total	Max	Man	Total
I1	25	24	49	12	11	23	12	6	18	49	41	90
I2	21	24	45	11	13	24	10	6	16	42	43	85
C	23	28	51	13	13	26	9	4	13	45	45	90
P3	23	26	49	18	19	37	8	5	13	49	50	99
P4	27	25	52	16	20	36	4	10	14	47	55	102
M1	20	20	40	23	28	51	5	9	14	48	57	105
M2	22	21	43	18	30	48	6	12	18	46	63	109
M3	13	19	32	11	21	32	3	4	7	27	44	71
Total	174	187	361	122	155	277	57	56	113	353	398	751

Sex

	Males			Females			Unknown			Total		
	Max	Man	Total	Max	Man	Total	Max	Man	Total	Max	Man	Total
I1	17	16	33	16	16	32	16	9	25	49	41	90
I2	14	16	30	17	18	35	11	9	20	42	43	85
C	16	17	33	18	21	39	11	7	18	45	45	90
P3	16	18	34	18	25	43	15	7	22	49	50	99
P4	18	20	38	19	23	42	10	12	22	47	55	102
M1	18	22	40	16	19	35	14	16	30	48	57	105
M2	17	23	40	15	22	37	14	18	32	46	63	109
M3	13	20	33	6	19	25	8	5	13	27	44	71
Total	129	152	281	125	163	288	99	83	182	353	398	751

the tooth taken at its greatest point. Tooth breadth is defined as the greatest distance in the buccolingual (BL) plane. These diameters and their product (crown area), are determined by methods described by Wolpoff (1971). All measurements were made by Lukacs with a Helios needle-point dial caliper calibrated to 0.05 mm, and crown diameters were rounded to the nearest 0.1 mm. Assessment of intra-observer accuracy is based on repeated measurement of the left side of 30 randomly selected plaster casts. Measurement sessions were separated by a period of ten months. Mean intra-observer difference is –0.06 mm. (s.d. = 0.18), a figure similar to those reported by other investigators (Hemphill 1991; Keiser et al. 1986; Kolakowski and Bailit 1981).

Pathological conditions of the permanent teeth and jaws were also assessed by Lukacs. Pathological conditions investigated include: abscesses, antemortem tooth loss (AMTL), calculus, caries, hypoplasia, hypercementosis, pulp exposure, and alveolar resorption. Methods for assessing the degree of expression of these conditions have been described elsewhere (Lukacs 1989; Lukacs et al. 1989). Frequencies of pathological conditions are assessed by individual count and by tooth count.

Twenty morphological features of the permanent dental crown were assessed for 55 tooth-trait combinations by Lukacs in accordance with criteria set forth by Lukacs and Hemphill (1991a). Intra-observer variation was assessed by repeated scoring of 35 tooth-trait combinations in a random sample of 50 plaster dental casts. Observation sessions were separated by more than one year, and the methods used in quantifying observer variation were those recommended by Nichol and Turner (1986). For each discrete trait four percentages were calculated, and the mean for these four measures of intra-observer error are well within those quoted by Nichol and Turner (1986).

Frequencies of dental traits were calculated for each grade of expression present in the Harappan sample according to the individual count method of Scott (1973, 1977, 1980), and trait expression was dichotomized into presence/absence only for comparison with other South Asian dental series (Table 11.4). In contrast to the method of Sofaer et al. (1986), only tooth-trait combinations scored in all dental series were considered. If a specific trait was completely absent in more than half of the series examined, it was eliminated from consideration. While Sjøvold (1973) accepts a trait if it is present in only one of the samples under consideration, we felt that with the small sample sizes available retention of infrequent variables would unduly magnify the influence of chance occurrence of rare traits. These criteria resulted in a reduction of dental morphology traits included in the comparative analysis to ten traits scored as 16 tooth-trait combinations. In most cases, any degree of trait development was considered a positive expression. The only exception to this pattern is hypocone development, for which only full expressions were scored as positive manifestations.

Contingency chi-square statistics were calculated to determine whether these non-metric dental traits detect significant heterogeneity in specific trait frequencies across all seven dental samples. If the number of significant differences exceeds the number of differences expected by chance alone, these traits were accepted as providing adequate data for determining patterns of relative similarity between these samples.

To place the R37C sample in regional perspective, affinities between sites were assessed by three different statistical methods. Trait frequencies based on presence/absence dichotomization were arcsine transformed according to the formula recommended by Green and Suchey (1976) to stabilize sample variance.

In the first method, arcsine transformed trait frequencies were used as input for cluster analysis, and dendrograms were constructed in euclidian space with Ward's minimum variance technique (Ward 1963). In the second method, mean measure of divergence distances were calculated between each sample pair by means of the formula recommended by Green and Suchey (1976). The standard deviation of these distances were calculated according to the method of Sjøvold (1973), and standardized divergence distances were calculated by dividing the mean measure of divergence of a specific comparison by its standard deviation. These standardized distances are more

Table 11.4. Dental Non-Metric Sample Sizes and Sources

Sample	Abbrev.	Date	N_{max}	Source
Harappa	HAR	Harappan phase	33	This Report
Chalcolithic Mehrgarh	MR2	4500 B.C.	25	Lukacs and Hemphill (1991a)
Neolithic Mehrgarh	MR3	6000 B.C.	49	Lukacs (1988)
Inamgaon	INM	1600-700 B.C.	41	Lukacs (1987)
Mahadaha	MDH	8000 B.C.	11	Lukacs and Hemphill (1991b)
Timargarha	TMG	1400-850 B.C.	21	Lukacs (1983)
Sarai Khola	SKH	200-100 B.C.	25	Lukacs (1983)

appropriate for evaluating and comparing relative distances in cases where widely different sample sizes are involved (Sofaer et al. 1986). Since the pattern of variation of seven different samples from one another—involving 21 different standardized distances—is difficult to visualize, standardized distances were used as input for multidimensional scaling. Kruskal's Stress Formula One (Kruskal 1964) was used, and results were ordinated into three dimensional space.

The third method used to examine group affinities between dental samples is principal components analysis. Arcsine transformed trait frequencies were standardized to have a zero mean and unit variance prior to submission to principal components analysis. Unrotated principle components were used since varimax rotation (Kaiser 1958) served to reduce the percentage of the total variance explained by the first three principal components and offered no improvement in interpreting the patterning of component loadings. Factor score coefficients (eigenvector coefficients) for each variable were multiplied by the standardized arcsine transformed frequency for each sample. These values were summed for each sample according to each of the first three principal components. The resulting scores were plotted into three dimensions to illustrate the position of each sample in multicomponent space.

Analysis of cranial non-metric traits was performed in a manner similar to that described for non-metric traits of the permanent teeth. Twenty-seven non-metric traits were scored for adult individuals in the R37C sample by Hemphill according to the criteria of Berry and Berry (1967). Because of small sample size, fragmentary condition of specimens, and for greater comparability with previously published reports, traits were scored by side, and only full expressions of traits were considered positive manifestations.

In the comparative phase of analysis, the frequency of cranial non-metric traits in the R37C sample were compared with ten other samples from South Asia and the Near East (Table 11.5). Only those samples scored by other workers in accordance with the criteria of Berry and Berry (1967) were accepted. As with dental non-metric variables, each cranial trait had to be considered in every sample in order to be included in the comparative analysis. This resulted in the elimination of two traits (*foramen ovale* incomplete, *foramen spinosum* open). In addition, those traits completely absent in more than half of the samples were eliminated. This resulted in elimination of five traits (bregmatic ossicle, auditory exostoses, bifaceted occipital condyle, palatine torus, maxillary torus). Finally, traits which may be the product of muscular development (highest nuchal line) or whose positive manifestations are subject to widespread differing interpretations (supraorbital foramen complete) were eliminated from consideration. These criteria resulted in a reduction in the number of cranial non-metric traits considered to 18 traits. Chi-square statistics were calculated to detect significant differences in individual trait frequencies across all samples. As described for non-metric dental traits, if the number of significant differences exceeds the number of differences expected by chance, these non-metric cranial variables were considered viable data for examining patterns of inter-group variation. Affinities between cranial series was accomplished with the same three methods described for dental non-metric traits.

All adult crania derived from the Harappan phase cemetery were assessed for 30 metric variables by Kennedy. All measurements have been standardized by both the Biometrika school and by Martin and Saller (1957). Only those variables for which data are available for either males or females in each sample were accepted. This reduced the number of variables considered to fourteen. Samples were then divided by sex and mean values obtained.

Comparative analysis of craniometric variation is in three parts. In the first part, craniometric variation encompassed by samples from two excavation efforts

Table 11.5. Cranial Non-Metric Sample Sizes and Sources

Sample	Abbrev.	Date	N_{max}	Source
Harappa	HAR	Harappan phase	24	This Report
Egyptian	EPT	4000-0 B.C.	250	Berry and Berry (1967)
Ancient Palestinian	APAL	700 B.C.	54	Berry and Berry (1967)
Modern Palestinian	MPAL	Modern	18	Berry and Berry (1967)
Punjabi	PUN	Modern	53	Berry and Berry (1967)
Burmese	BUR	Modern	51	Berry and Berry (1967)
Mahadaha	MDH	8000 B.C.	11	This Report
Lidar	LDR	2300-2000 B.C.	25	Klug and Wittwer-Bakofen (1985)
Kamid el-Loz	KEL	500 B.C.	47	Klug and Wittwer-Bakofen (1985)
Sarai Khola	SKH	200-100 B.C.	26	Klug and Wittwer-Bakofen (1985)
Bedouin	BED	Modern	35	Henke and Disi (1981)

in the Harappan phase cemetery (R37A, R37C) and from two different burial contexts in the Late Harappan cemetery ("H1JAR" = Stratum I—upper jar/pot burials, "H2OPEN" = Stratum II—lower earth burials) are compared against five other prehistoric skeletal series from Pakistan. This phase of analysis seeks to determine the level of within-site variability at Harappa relative to the level of variation encompassed by other prehistoric samples from Pakistan. Samples were divided by sex, and analysis of variance was used to determine whether these craniometric variables detect significant differences across these six samples. As with cranial and dental non-metric traits, if the number of significant differences exceeds the number of differences expected by chance, these variables were accepted as providing adequate data for determining patterns of relative similarity among these prehistoric groups.

Two methods were used to assess relative affinity by sex among prehistoric groups from Pakistan. In the first method, sex-specific mean parameter values were submitted to cluster analysis, and dendrograms were constructed for males and for females in euclidean space with Wards' minimum variance technique. Only those variables for which data were available in all samples were accepted. This criteria resulted in a reduction in the number of variables considered to ten for females and eleven for males. In the second technique, group sex-specific mean parameter values used in cluster analysis were submitted to principal components analysis. These values were standardized by sex across groups to have a zero mean and unit variance. Unrotated principle components were derived, and factor score coefficients (eigenvector coefficients) for each variable were multiplied by the standardized mean parameter value for each sample. These values were summed for each sample by sex according to each of the first three principal components, and resulting scores were ordinated into three dimensions to illustrate the position of each sample in multicomponent space.

The second phase of analysis examines the level of craniometric variation among living and prehistoric South Asians. Samples of modern Veddahs, Nepalese, and Tibetans were compared with the six prehistoric samples from Pakistan used in the first phase of analysis. Samples from the Harappan phase cemetery were pooled, but the two samples from Late Harappan phase Cemetery H were considered separately. These latter samples were considered separately in order to determine if differences in inhumation practices are accompanied by differences in biological affinities. The earlier burials of the Late Harappan cemetery are extended burials with pottery arranged at the head or feet. In the upper levels of the cemetery the burials are secondary inhumations in pots/jars. To control for different sex ratios presented by each sample, group values were calculated as the average between male and female means for each craniometric variable. Group mean values were submitted to cluster analysis, and dendrograms were constructed in euclidean space with Ward's minimum variance technique. Principal components analysis was used to provide a check on the patterns of affinity derived from cluster analysis as well as to gain additional insight into the pattern of variation among these modern and prehistoric South Asian samples.

In the final phase, South Asian craniometric variation is placed in regional perspective by contrasting South Asian cranial series against prehistoric samples from Egypt, Anatolia, Mesopotamia, and the Iranian Plateau (Table 11.6). To provide maximum comparability, the same variables used to examine within-South Asian cranial variation were employed. Group values were derived in the same manner described for South Asian samples, and these values were submitted to cluster analysis and principal components analysis for assessment of biological affinities.

Results

Odontometrics

Mean mesiodistal and buccolingual crown diameters for the sex-pooled sample obtained from R37 are presented in Table 11.7. A paired-samples t-test was used to test for significant differences in tooth size between left-right tooth pairs. Only two crown diameters (LI2MD, LM3MD) exhibit significant differences between right and left antimeres. Since this number of significant differences falls below the number of significant differences expected from chance ($p < 0.05$), mean values presented in Table 11.7 reflect measurements from the left side only.

Mean crown areas (in mm^2) by side are also presented in Table 11.7. Means for right and left sides are nearly equal, confirming the lack of asymmetry found by paired-samples t-tests of individual parameters. Summed crown areas by jaw reveal that maxillary teeth (631 mm^2) are slightly larger than their mandibular isomeres (567 mm^2). When mean crown areas for both right (1189 mm^2) and left (1198 mm^2) are considered, individuals from the Harappan phase cemetery possess an overall tooth size of 1194 mm^2.

Total crown area is used to place the tooth size of the inhabitants of the Harappan phase cemetery in perspective with regard to other South Asian dental series. Differences in total crown area are presented in two ways: as a histogram of total crown area (Figure 11.2), and as a bivariate plot of total tooth size against

Table 11.6. Craniometric Sample Sizes and Sources

Sample	Abbreviation	Date	N_{max}	Source
Harappa: Cemetery R37A	R37A	Harappan phase	34	Gupta et al. (1962)
Harappa: Cemetery R37C	R37C	Harappan phase	30	This Report
Harappa: Cemetery H upper (jar/pot)	H1(JAR)	Late Harappan	15	Gupta et al. (1962)
Harappa: Cemetery H lower (open/earth)	H2(OPEN)	Late Harappan	13	Gupta et al. (1962)
Chatal Hüyük	CHY	5000-64 B.C.	12	Krogman (1949)
Tell al-Judiadah	TAJ	5000-64 B.C.	19	Krogman (1949)
Kish	KISH	2900-2800 B.C.	27	Buxton and Rice (1931)
Tepe Hissar II	TH2	3500-3000 B.C.	16	Krogman (1940)
Tepe Hissar III	TH3	3000-2000 B.C.	138	Krogman (1940)
Naqada	NAQ	7000-5000 B.C.	407	Fawcett and Lee (1901)
Abydos	ABY	1st Dynasty	47	Morant (1925)
Badaria	BAD	Predynastic	58	Stoessiger (1927)
Nepalese	NEP	Modern	56	Morant (1924)
Tibetans	TIB	Modern	25	Morant (1924)
Sedment	SED	9th Dynasty	70	Woo (1930)
Mohenjo-daro	MHD	Harappan phase	16	Sewell and Guha (1931) Guha and Basu (1938)
Timargarha	TMG	1400-800 B.C.	20	Bernhard (1967)
Veddahs	VED	Modern	62	Osman Hill (1941)

Table 11.7. Crown Diameters and Areas of Permanent Teeth from the Harappan Phase Cemetery at Harappa (R37C) [left side in mm]

Maxilla

	Mesiodistal			Buccolingual			Crown Area		
	Mean	S.D.	N	Mean	S.D.	N	Mean	S.D.	N
I1	8.89	0.47	11	7.16	0.33	15	63.5	4.5	11
I2	6.80	0.58	10	6.48	0.59	12	43.1	9.0	9
C	7.82	0.42	10	8.23	0.39	13	63.4	3.7	9
P3	7.26	0.84	15	9.44	0.28	17	66.6	4.3	14
P4	6.75	0.47	22	9.29	0.41	22	63.2	6.3	21
M1	10.32	0.50	18	11.61	0.51	19	119.4	9.5	18
M2	9.59	0.68	18	11.01	1.08	15	110.7	12.3	17
M3							101.5	18.0	15

Mandible

	Mesiodistal			Buccolingual			Crown Area		
	Mean	S.D.	N	Mean	S.D.	N	Mean	S.D.	N
I1	5.53	0.23	10	5.91	0.16	14	32.5	1.8	10
I2	6.10	0.21	8	6.43	0.26	15	38.4	2.1	8
C	6.82	0.29	10	7.74	0.56	17	51.0	4.3	9
P3	6.75	0.37	17	7.79	0.47	22	52.1	4.8	17
P4	7.02	0.54	20	8.18	0.63	23	57.1	7.7	20
M1	11.18	0.64	16	10.59	0.47	19	117.9	10.3	16
M2	10.61	0.65	24	10.10	0.58	26	107.7	12.3	24
M3	10.38	0.73	15	9.69	0.54	16	101.1	12.3	15

time (Figure 11.3). A total crown area of 1194 mm^2 places Harappan (HAR) individuals just below the mean value (1215 mm^2) for eight South Asian groups, but well within one standard deviation (SD = 60.6 mm^2). Harappan phase individuals are most similar in overall tooth size to dental samples from Inamgaon and Timargarha, both of which date some 800 to 1000 years later.

Figure 11.3 provides a bivariate plot of tooth size in relation to antiquity among South Asians that permits

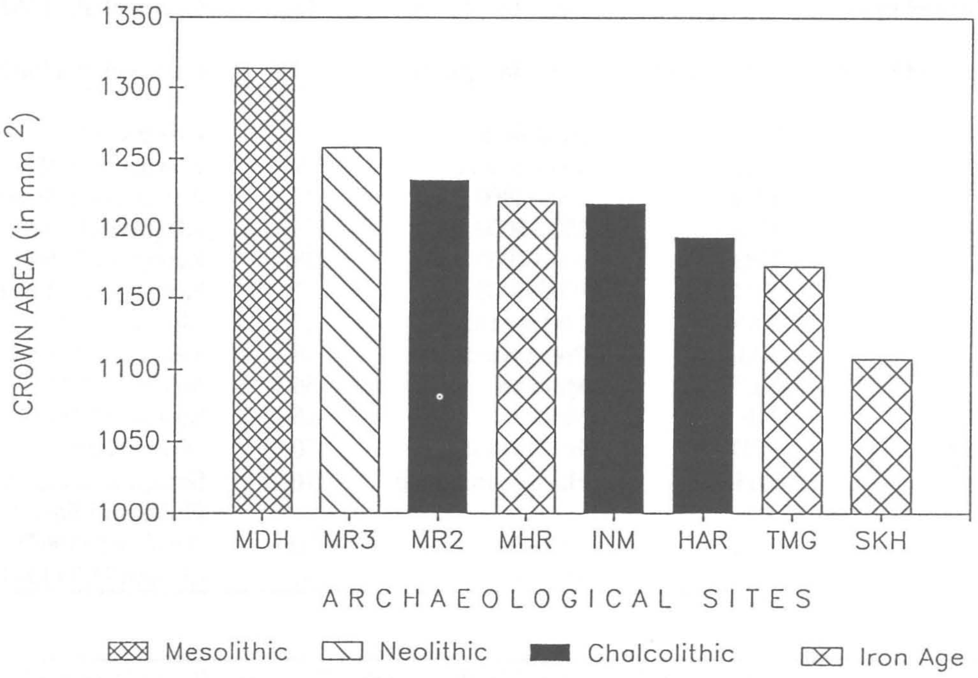

Figure 11.2. Tooth size variation among prehistoric South Asians (see Table 11.4 for abbreviations).

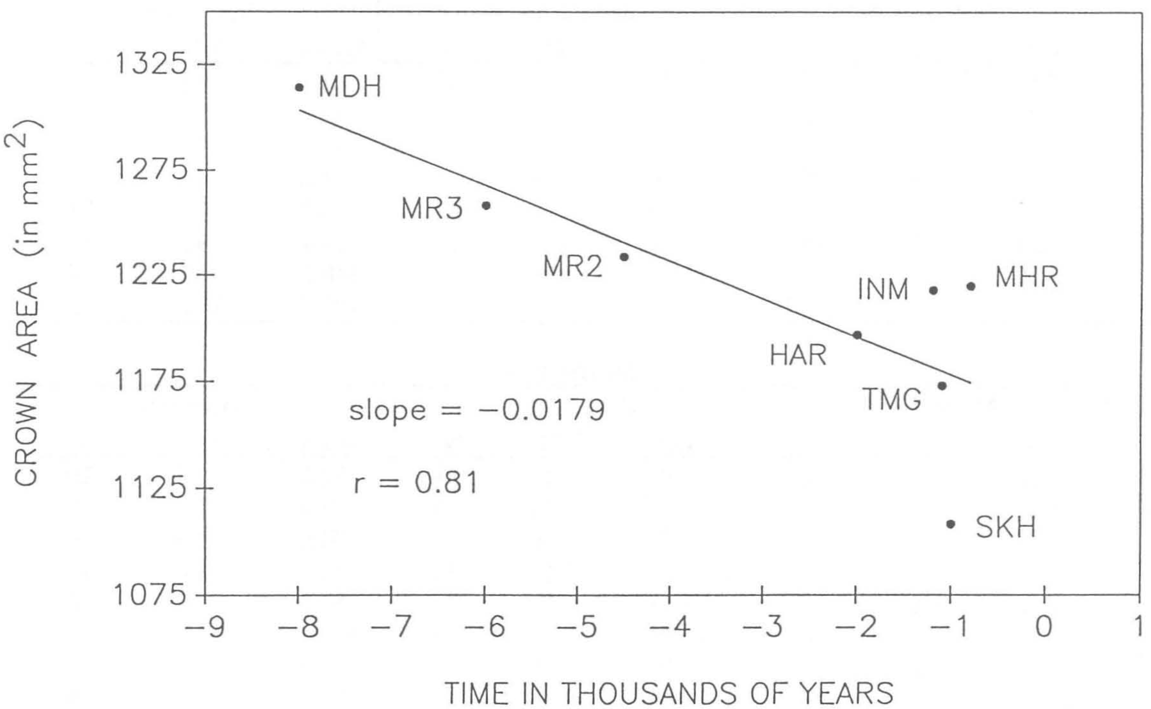

Figure 11.3. Tooth size reduction over time for prehistoric South Asians (see Table 11.4 for abbreviations).

closer examination of the relationship between tooth size, antiquity, and cultural type. This bivariate plot of sites by antiquity and by total crown area yields a correlation coefficient of 0.81 ($p < 0.01$). The negative slope of this regression ($y = -0.018x + 1160$) confirms the impression gained from the histograms presented in Figure 11.2, namely, that South Asians have experienced a progressive reduction in tooth size over time. In fact, these data indicate a dental reduction rate of about 18 mm^2 or 1.7% per 1000 years. This South Asian rate accords well with dental reduction rates recorded for other parts of the world (Brace et al. 1987) and provides a strong argument for a directional selectional relationship between technological development and tooth size reduction (Calcagno 1984; Calcagno and Gibson 1988; Frayer 1987; Lukacs 1982).

Dental Pathology

Documentation of dental pathological conditions among the Bronze Age cultures of the Old World is poor despite the availability of skeletal remains. This paucity of information is especially true in South Asia where description of dental remains from Harappa is woefully incomplete, and description of the dental remains from Kalibangan, Rupar, and Lothal have not yet been published.

Pathological conditions are reported in two different ways—by individual count and by total tooth count. Assessment of pathological affliction by individual count is a logical approach since the individual is the biological entity upon which natural selection acts. Unfortunately, in many prehistoric skeletal samples when the sample is divided by age and sex, the number of individuals available for study becomes too small for effective statistical testing. Assessment by total tooth count is a more logical approach when the effect of dental disease on specific tooth classes or by jaw is of importance. To maximize comparability with other studies, we have chosen to report our results both by individual count and by tooth count.

Individual count prevalence of eight dental pathological conditions by burial context and by sex among Harappan phase (R37C) individuals is presented in Table 11.8 and illustrated in Figure 11.4. Linear enamel hypoplasia, a disruption of enamel formation during tooth development caused by pathological affliction or dietary deficiencies (Goodman and Rose 1990), represents the most frequent dental disorder affecting over 70% of individuals recovered from the Harappan phase cemetery. While more hypoplastic lesions are present among females than among males, there is no difference in mean age of affliction (males = 4.3 years; females = 4.3 years). However, variance in age at affliction is much higher among girls (s.d. = 0.9 years) than among boys (s.d. = 0.7 years). This suggests that R37C girls were affected by growth disruptions across a wider age range than R37C boys. The least frequent disorder is hypercementosis, which affected only 5% of R37C individuals. Other afflictions of low prevalence include abscesses (18%) and pulp exposure (17%). Antemortem tooth loss (32%), calculus (43%), caries (44%), and alveolar resorption (53%) occur with intermediate frequency. Sex differences in pathological affliction were assessed by means of the chi-square test. Higher frequency of caries and pulp exposure among females, while not statistically significant ($p < 0.05$), is large and may be of biological significance.

Frequency of pathological affliction by tooth count is presented in Table 11.9. Dental abscesses are most common among premolar teeth (6.5%) and least common among molars (0.7%). A total of 70 teeth provide unequivocal evidence on antemortem loss. To provide the most accurate estimate of antemortem tooth loss frequency, the number of teeth known to have been lost during life (70), is divided by the total number of teeth present in the skeletal series prior to any tooth loss: that is, the total number of teeth observed (751) plus those teeth known to have been lost antemortem (70). Examined in this manner, antemortem tooth loss occurs with a frequency of 8.5%

Table 11.8. Prevalences of Dental Diseases in Individuals from the Harappan Phase Cemetery at Harappa (R37C) by Individual Count

	Males			Females			Unknown			Total		
	Pres.	N	Pct.	Pres.	N	Pct.	Pres.	N	Pct.	Pres.	N	Pct.
Abscesses	3	17	17.7	4	17	23.5	0	4	0.0	7	38	18.4
AMTL	3	17	17.7	9	19	47.4	1	5	20.0	13	41	31.7
Calculus	8	17	47.1	7	17	41.2	2	6	33.3	17	40	42.5
Caries	6	17	35.5	10	16	62.5	1	6	16.7	17	39	43.6
Hypoplasia	9	16	56.3	13	14	92.9	4	6	66.7	26	36	72.2
Hypercementosis	1	17	5.9	1	19	5.3	0	5	0.0	2	41	4.9
Pulp Exposure	2	16	12.5	5	19	26.3	0	6	0.0	7	41	17.1
Resorption	9	16	56.3	9	18	50.0	2	4	50.0	20	38	52.6

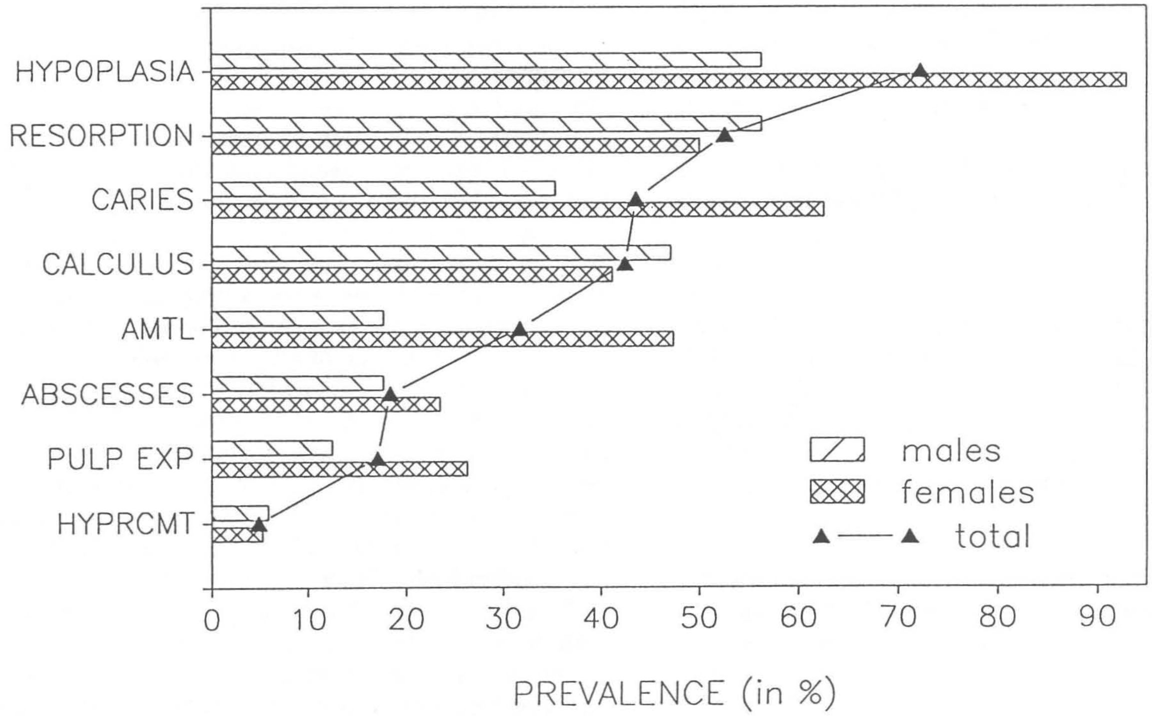

Figure 11.4. Dental pathologies by individual count by sex at Harappa.

Table 11.9. Prevalences of Dental Diseases in Individuals from the Harappan Phase Cemetery at Harappa (R37C) by Tooth Count

	Abscesses		AMTL		Caries		Pulp Exp.	
Tooth Class	N	Pct.	N	Pct.	N	Pct.	N	Pct.
I	4	2.29	9	4.89	4	2.29	6	3.43
C	4	4.44	10	1.10	6	6.67	6	6.67
P	13	6.47	14	6.51	11	5.47	17	8.46
M	2	0.70	46	13.90	30	10.53	8	2.81
Total	23	3.06	70	8.53	51	6.79	37	4.93
Sex								
Male	5	21.7*	13	20.3*	18	38.3	28	75.7*
Female	18	78.3	51	79.7	29	61.7	9	24.3
Jaw								
Maxilla	14	60.9	24	34.3*	32	62.7	28	75.7*
Mandible	9	39.1	46	65.7	19	37.3	9	24.3

*=p<0.05

(70/821). Molar teeth are most often affected (13.9%), while canines are very rarely affected (1.1%). When examined by jaw and by sex, antemortem tooth loss is significantly more common among mandibular teeth than maxillary teeth and more common among R37C females than among males.

Overall caries prevalence at Harappa is 6.8%. Caries affliction does not occur with uniformity throughout the dentition, for caries are much more common among maxillary teeth (9.1%) than mandibular teeth (4.8%), and among posterior teeth (molars and premolars: 8.4%) relative to anterior teeth (incisors and canines: 3.8%). Overall, males and females present a similar pattern of caries affliction with one notable exception: high frequency of caries among maxillary anterior teeth in females. This is a deviation in caries

prevalence patterns from those discovered in other populations, for caries are generally very rare among maxillary anterior teeth.

Exposure of the pulp cavity was found in 37 Harappan teeth (4.9%). Premolars are most often affected (8.5%), followed by canines (6.7%), with incisors least often affected (3.4%). Pulp exposures are significantly more common among maxillary teeth (75.7%) than among mandibular teeth (24.3%) and among females (75.7%) relative to males (24.3%). When pulp exposures are divided into those caused by caries and those caused through tooth wear, caries induced exposure (67.6%) occurs with double the frequency of exposures due to tooth wear (34.3%).

If the relative contribution of tooth wear and caries for exposure of the pulp are considered along with the frequency of antemortem tooth loss, a more accurate assessment of actual caries affliction may be obtained (Lukacs 1991). This "caries correction factor" estimates the amount of antemortem tooth loss due to caries (67.7% of 70 teeth lost antemortem: 48 caries induced antemortem tooth losses). If this number of caries induced losses (48) is added to the number of observed caries affected teeth (51) the number of teeth actually affected by caries is 99. This number of caries affected teeth yields a new corrected caries rate of 12.1% among R37C individuals (99/851). While other factors, such as alveolar resorption, traumatic injury, and ritual ablation, may lead to antemortem tooth loss, these conditions are extremely rare among Harappans. Therefore, we regard the caries correction estimate (12.1%) to be a more accurate indicator of the true caries prevalence among Harappans.

Comparison of the dental pathology profile among individuals interred in the Harappan phase cemetery at Harappa with other prehistoric skeletal series from South Asia is performed to examine the relationship between increasing reliance upon cultivated foodstuffs and patterns of dental disease. In this comparative study all pathology data, except from Bellan Bandi Pallasa (Kennedy 1965), were collected by Lukacs. Sites for which comparative data are available range from mesolithic hunter-gatherers at Mahadaha, Sarai Nahar Rai, and Lekhahia (Lukacs and Hemphill 1991b) to the fully agricultural inhabitants of Sarai Khola (Lukacs et al. 1989). Other dental pathology data are available from neolithic and chalcolithic levels at Mehrgarh (Lukacs 1985a; Lukacs et al. 1985), Timargarha (Lukacs et al. 1989), Pomparippu (Lukacs 1976), and Mahurjhari (Lukacs 1981).

The first stage of this comparative analysis focuses on dental pathology and agricultural intensification within the Indus Valley and utilizes sites which feature adequate sample sizes and similar age at death profiles. Comparison of frequencies of dental pathologies at the Harappan phase cemetery to neolithic and chalcolithic skeletal series from Mehrgarh is presented in Figure 11.5. Pathological conditions are arranged from left to right according to decreasing frequency in the Harappa sample. In all three series, linear enamel hypoplasia represents the most common pathological condition, but Harappans possess the highest levels of the three groups compared.

The second phase of this comparative analysis examines caries frequency among prehistoric South

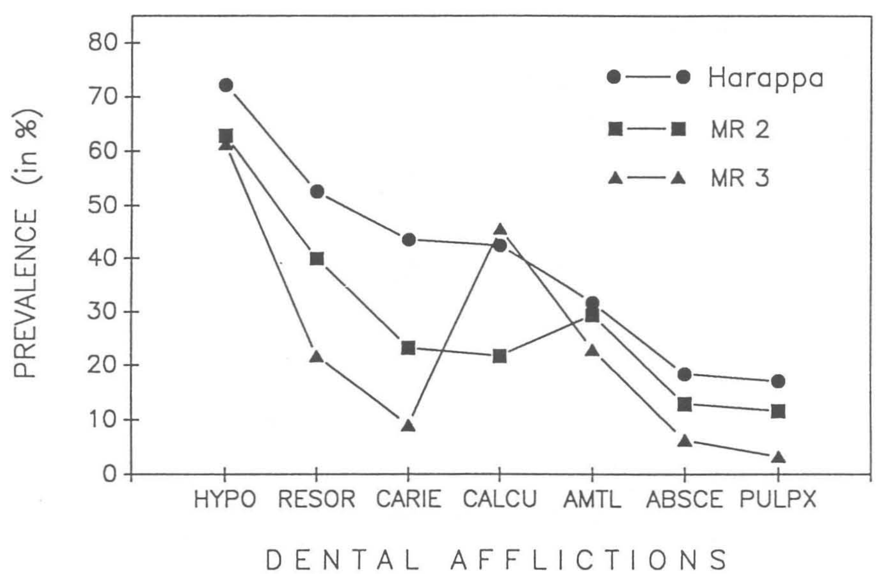

Figure 11.5. Dental pathologies among prehistoric Indus Valley sites by individual count.

Asian dental series. Figure 11.6 reveals that mesolithic caries rates are uniformly low (0.0 to 1.2%), while caries frequency among Iron Age sites is much higher (4.4 to 7.7%). The uncorrected caries rate among R37C (HAR) individuals falls within the range exhibited by Iron Age sites, but when the caries correction factor is used, R37C individuals possess caries at two times the rate of the Iron Age series average (6.1%). The progressive decline in dental health, exhibited by increasing caries rates from neolithic Mehrgarh, to chalcolithic Mehrgarh, to Harappa, reflects the combined influence of both increasing reliance upon cultivated foodstuffs and gradual but significant improvements in food processing technology.

Craniometrics

Fourteen craniometric variables were used to assess similarities among prehistoric samples from Pakistan. Analysis of variance results, adjusted for several instances of incomplete data sets, indicate that, with six significant differences among females (6/14 = 42.9%) and three significant differences among males (3/14 = 21.4%), these variables successfully distinguish differences among these groups (Table 11.10). Mean values were calculated for each group by sex and submitted to cluster analysis (Figure 11.7). Lack of data within several samples when grouped by sex resulted in the elimination of four variables among females and three variables among males.

Cluster analysis of sex-specific mean parameter values reveals that both males and females from prehistoric sites in Pakistan demonstrate a clear dichotomy between those samples derived from northern Pakistan and the only sample from southern Pakistan (Mohenjo-daro). Within northern Pakistan, differences among males and females differ. While both sexes indicate that the two samples from the Harappan phase cemetery at Harappa (R37A and R37C) bear closer affinities to other samples from northern Pakistan than to one another, analysis of male and females differ as to the patterning of these affinities. R37A males appear most similar to post-Harappan males from Timargarha, while R37C males are most closely affiliated with males from Late Harappan upper (jar) burials in Cemetery H (H1). Males from the lower (earth) burials in Cemetery H (H2) are only peripherally associated with these other four samples from northern Pakistan, but are nevertheless much more proximate to these samples than to males from Mohenjo-daro.

The pattern of relationships found among prehistoric females also indicates that the five samples from northern Pakistan are more similar to one another than any are to females from Mohenjo-daro. However, patterns of affinity among females from northern Pakistan differ from those found among males. Again, the two samples from the Harappan phase cemetery bear closer affinity to other samples from northern Pakistan than to one another. R37A females are most proximate to females derived from lower (earth) burials at Cemetery H (H2), while R37C females bear closest affinities to females from Timargarha. Females derived from upper (jar) burials at Cemetery H (H1) are identified as possessing only peripheral affinities to other females from northern Pakistan, but are

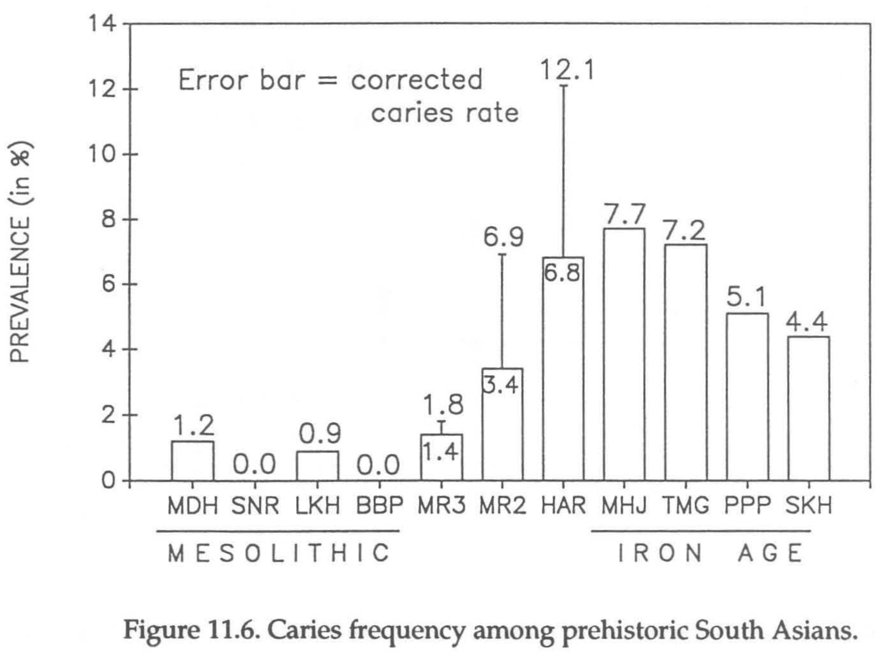

Figure 11.6. Caries frequency among prehistoric South Asians.

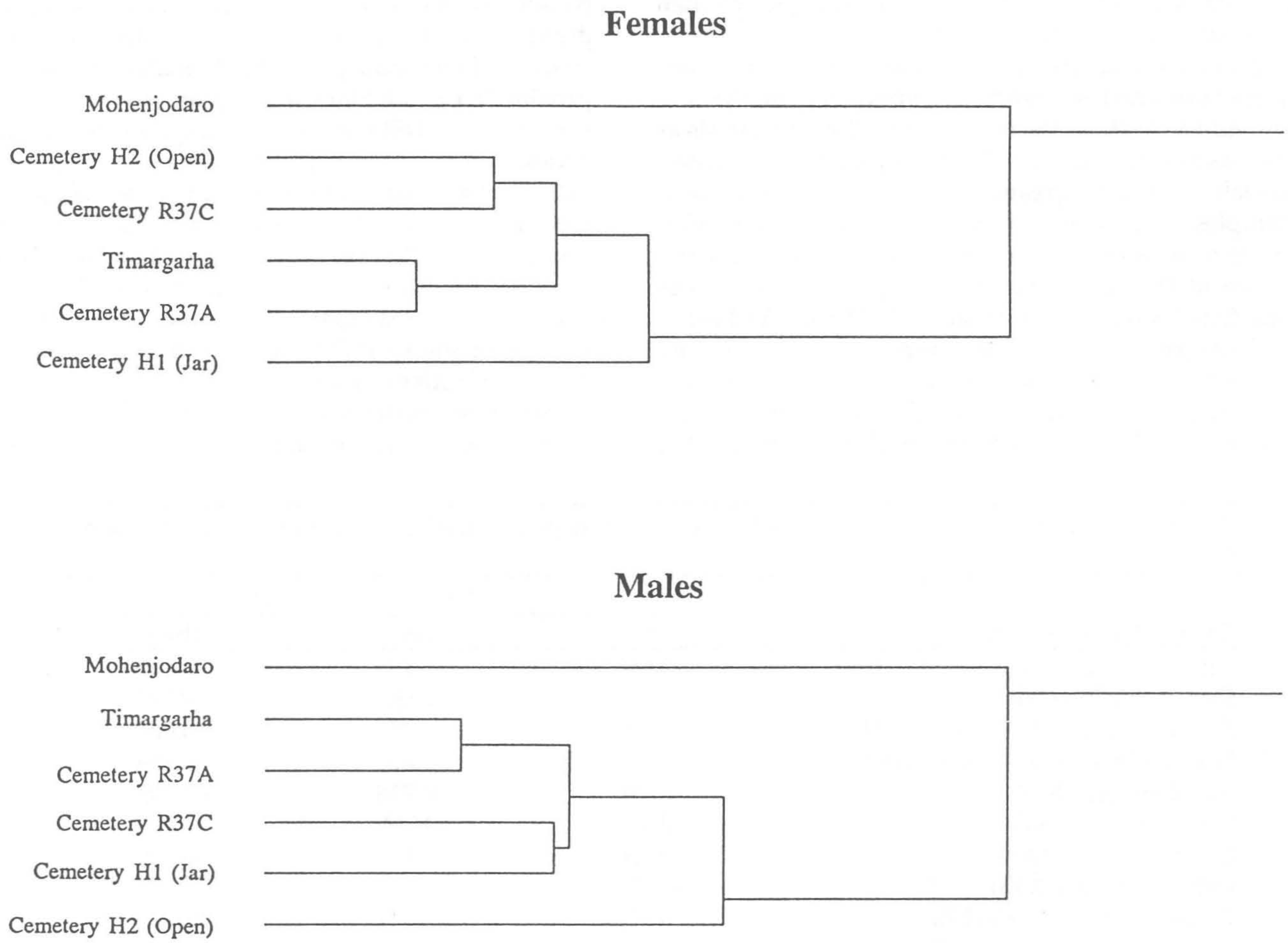

Figure 11.7. Cluster analysis of craniometric variation among prehistoric peoples from Pakistan by sex.

Table 11.10. Analysis of Variance of Cranial Measurements Among Prehistoric Peoples from Pakistan by Sex

	Females			Males		
Craniometric Measurement	F	p	N	F	p	N
Glabello-Occipital Length (GOL)	0.704	0.623	57	0.398	0.847	45
Bieuryonic Breadth (BEB)	3.032	0.019*	51	3.053	0.022*	41
Auricular Height (AVH)	2.206	0.072	48	1.411	0.248	37
Sagittal Arc (SA)	2.444	0.055	39	0.443	0.815	38
Circumference Above Browridges (CAB)	3.407	0.012*	46	0.790	0.565	36
Bifrontotemporale Breadth (BFTB)	2.327	0.056	57	0.677	0.644	42
Nasio-Prosthion Height (NPH)	2.744	0.033*	44	1.002	0.430	42
Nasal Height (NH)	0.742	0.596	55	1.362	0.259	45
Nasal Breadth (NB)	2.343	0.055	55	3.777	0.008*	41
Orbital Height (OH)	1.016	0.418	59	1.752	0.146	44
Orbital Breadth (OB)	1.557	0.189	56	3.172	0.017*	45
Bizygomatic Breadth (BZB)	2.881	0.035*	31	0.624	0.683	27
Internal Palatal Length (IPL)	2.635	0.044*	35	1.622	0.187	34
Internal Palatal Breadth (IPB)	6.636	0.000*	36	1.032	0.417	36

$^{*} = p < 0.05$

nevertheless much more similar to these groups than they are to females from Mohenjo-daro.

Standardized sex-specific mean parameter values were submitted to principal components analysis to provide a check on the results from cluster analysis as well as to gain some insight into what combinations of variables lead to greatest segregation among these samples. Principal components analysis identifies three components that combine to explain 85.2% and 92.3% of the total variance among prehistoric males and females respectively (Tables 11.11a and 11.11b).

Ordination of principal component scores among prehistoric males and females from Pakistan are presented in Figure 11.8. In agreement with cluster analysis, Mohenjo-daro males are clearly identified as possessing the most distant affinities among these groups. Also in agreement with results from cluster analysis, Harappan phase R37C males appear more proximate to Late Harappan upper (jar) burials from Cemetery H (H1) than to Harappan phase R37A males. However, in contrast to cluster analysis, ordination of principal component scores does not indicate that lower (earth) burials from Late Harappan Cemetery H (H2) possess only peripheral affinities to other males from northern Pakistan. Rather, males from the lower (earth) burials exhibit close affinities to Harappan phase R37A males and somewhat more distant affinities to males from Timargarha. Principal components analysis suggests that Harappan phase R37C males represent a peripheral member of the

Table 11.11a. Principal Components Analysis of Craniometric Variation among Prehistoric Females from Pakistan

	Principal Component		
Cranial Measurement	One	Two	Three
Glabello-Occipital Length (GOL)	0.945	0.196	0.190
Bieuryonic Breadth (BEB)	0.972	-0.133	0.187
Bifrontotemporale Breadth (BFTB)	0.990	0.021	0.065
Nasion-Prosthion Height (NPH)	0.065	0.874	0.458
Nasal Height (NH)	0.470	0.718	-0.338
Nasal Breadth (NB)	0.890	-0.264	-0.256
Orbital Height (OH)	0.900	0.264	0.200
Orbital Breadth (OB)	-0.676	0.629	0.128
Bizygomatic Breadth (BZB)	0.715	0.272	-0.629
Internal Palatal Breadth (IPB)	-0.587	0.411	-0.491
Eigenvalue	5.959	2.115	1.159
Percentage of Variance Explained	59.587	21.147	11.589
Total Variance Explained		92.323	

Table 11.11b. Principal Components Analysis of Craniometric Variation among Prehistoric Males from Pakistan

	Principal Component		
Cranial Measurement	One	Two	Three
Glabello-Occipital Length (GOL)	-0.631	0.642	-0.121
Bieuryonic Breadth (BEB)	0.526	-0.140	0.665
Bifrontotemporale Breadth (BFTB)	-0.801	0.355	0.476
Nasion-Prosthion Height (NPH)	0.815	0.274	-0.307
Nasal Height (NH)	0.714	0.355	0.244
Nasal Breadth (NB)	-0.425	0.082	0.823
Orbital Height (OH)	0.668	0.743	0.028
Orbital Breadth (OB)	0.548	0.715	0.075
Bizygomatic Breadth (BZB)	0.937	-0.310	0.124
Internal Palatal Length (IPL)	-0.805	0.408	-0.258
Internal Palatal Breadth (IPB)	0.852	0.060	-0.002
Eigenvalue	5.669	2.188	1.603
Percentage of Variance Explained	51.539	15.626	14.575
Total Variance Explained		85.150	

northern Pakistani group, whose closest affinities lie with males derived from the upper (jar) burials at Cemetery H (H1).

Ordination of group component scores among females from prehistoric Pakistan also demonstrates a strong separation between groups from northern Pakistan and the single sample from southern Pakistan. Closest affinities among northern groups occur between Harappan phase R37A females and females from post-Harappan Timargarha, followed by Harappan phase R37C females. Females derived from the lower (earth) burials at Cemetery H (H2) occupy an intermediate position between these groups and females derived from the upper (jar) burials at this cemetery (H1).

Together, cluster analysis and principal components analysis among prehistoric samples from Pakistan provide good separation between samples from southern Pakistan and those from northern Pakistan. All males and females from the north exhibit relatively close affinities to one another, except for Harappan phase R37C males and females from upper (jar) burials at Cemetery H (H1), both of which possess rather peripheral affinities to other northern Pakistani samples.

In the second phase of analysis, variation among prehistoric samples from Pakistan is examined relative to several modern samples derived from the periphery of South Asia. The two samples from the Harappan phase cemetery were pooled, but the two samples from Cemetery H were considered separately. This was done to reflect the similarities in interment practices at the Harappan phase cemetery (R37) as well as to examine any possible correlation between interment practice and biological affinities in the Late Harappan cemetery (H). Adjusted for cases of incomplete data, analysis of variance indicates that with twelve significant differences among females (12/14 = 85.7%) and fourteen significant differences among males (14/14 = 100.0%), these craniometric variables provide adequate data for distinguishing between the eight South Asian cranial samples considered (Table 11.12). Few of these comparisons (4/28 = 14.3%) exceed the level of inter-group variance heterogeneity that could compromise these results. Therefore, despite small samples a significant amount of heterogeneity in craniometric variation is present among South Asians.

Group mean parameter values for each sample were calculated by taking the average between male and female average values for each variable. These values are presented in Table 11.13. Cluster analysis of group mean parameter values indicates that these eight South Asian samples fall into two main groups (Figure 11.9). The first includes all northern Pakistani sites, while the second includes Tibetans, Nepalese, Veddahs, and Mohenjo-daro. This represents a nearly

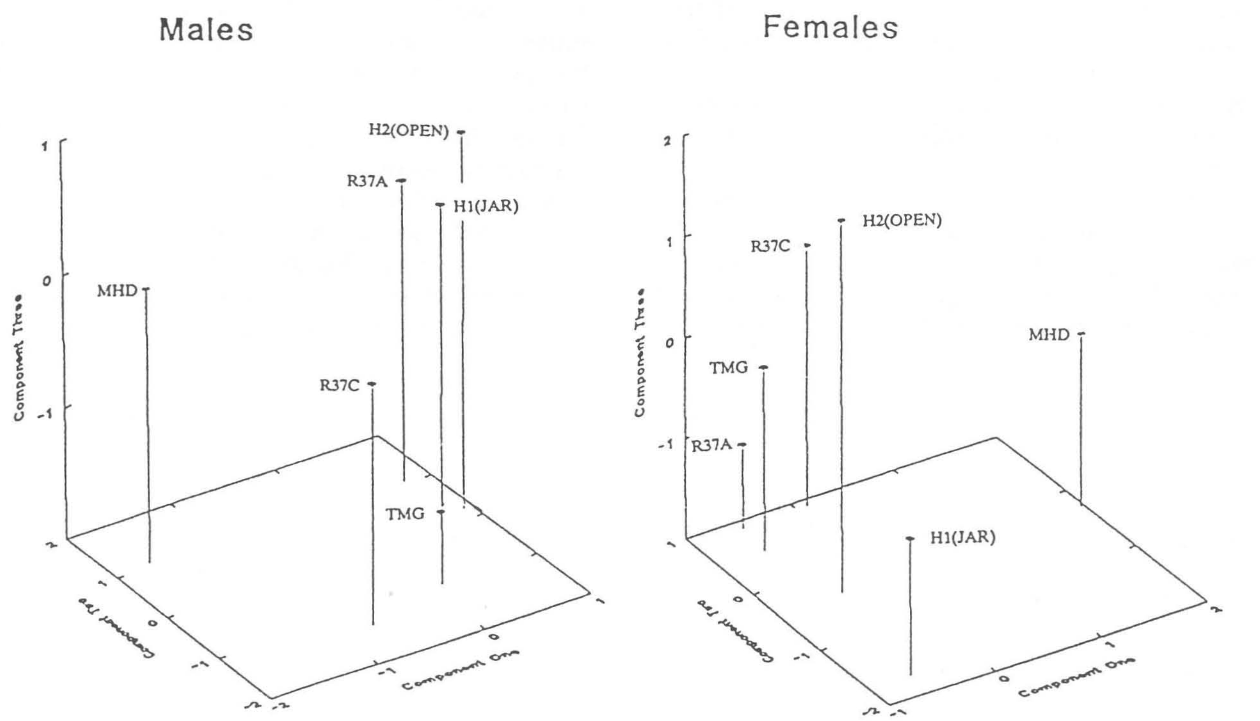

Figure 11.8. Ordination of principal component scores derived from craniometric variation among prehistoric peoples from Pakistan by sex.

Table 11.12. Analysis of Variance of Cranial Measurements among South Asians by Sex

	Females			Males		
Craniometric Measurement	F	p	N	F	p	N
Glabello-Occipital Length (GOL)	6.988	0.000*	85	11.216	0.000*	156
Bieuryonic Breadth (BEB)	5.574	0.000*	79	14.181	0.000*	153
Auricular Height (AVH)	2.107	0.055	72	3.743	0.001*	138
Sagittal Arc (SA)	4.527	0.001*	58	5.183	0.000*	132
Circumference Above Browridges (CAB)	8.025	0.000*	73	10.800	0.000*	147
Bifrontotemporale Breadth (BFTB)	4.416	0.000*	84	4.043	0.000*	154
Nasio-Prosthion Height (NPH)	6.541	0.000*	69	9.912	0.000*	145
Nasal Height (NH)	3.354	0.004*	77	8.050	0.000*	154
Nasal Breadth (NB)	2.515	0.023*	79	3.605	0.001*	150
Orbital Height (OH)	3.397	0.003*	83	1.137	0.343	155
Orbital Breadth (OB)	5.665	0.000*	79	5.760	0.000*	156
Bizygomatic Breadth (BZB)	3.075	0.010*	52	6.318	0.000*	132
Internal Palatal Length (IPL)	2.379	0.036*	57	6.867	0.000*	126
Internal Palatal Breadth (IPB)	2.097	0.067	56	4.420	0.000*	129

* = $p < 0.05$

complete division of samples between those of the Indus Valley and those coming from other parts of South Asia. Mohenjo-daro is the sole exception to this division. Individuals from the Harappan phase cemetery possess closest affinities to Timargarha and to lower (earth) burials at Cemetery H (H2). Upper (jar) burials at Cemetery H (H1) bear only a peripheral relationship to these three samples. Clearly, the two Late Harappan samples do not bear closest relations to one another, the result expected if these samples are representative of the same population. Note, however, that the sample sizes are not large: 15 for jar burials (H1) and 13 for earth burials (H2).

Principal components analysis yields three components that combine to explain 87.2% of the total variance (Table 11.14). The first component draws a distinction between measurements of the neurocranium and face with those of the palate, with the former receiving high loadings and the latter low loadings. Consequently, high scorers along the first component reflect samples that possess relatively large neural and facial measurements in combination with rather small palatal measurements. The second component draws a distinction between paired length and breadth measurements. Cranial length, nasal height, orbital height, and internal palatal length all possess higher loadings than cranial breadth, nasal breadth, orbital breadth, and internal palatal breadth. Thus, high scorers for component two feature relatively long cranial vaults, coupled with narrow nasal apertures, eye orbits, and palates. The distinction drawn by the third component is somewhat similar to that drawn by the second, but in this case breadth measurements are contrasted with measurements of cranial and facial height. Consequently, high scorers for component three are marked by relatively low cranial vaults, faces, nasal apertures, and eye orbits.

Two and three dimensional ordination of principal component scores (Figure 11.10) confirm the nearly complete division between Indus Valley samples and samples coming from other parts of South Asia. With

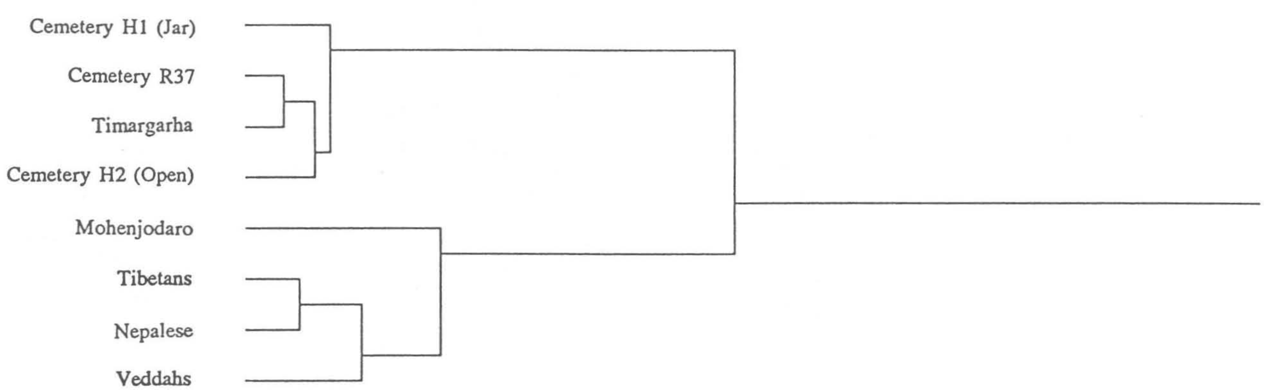

Figure 11.9. Cluster analysis of craniometric variation among South Asians.

Table 11.13. Group Mean Parameters for Cranial Measurements among All Groups

	Abydos (ABY)		Badaria (BAD)		Chatal Hüyük (CHY)		Cemetery H (H1JAR)		Cemetery H (H2OPEN)		Kish (KISH)		Mohenjo-daro (MHD)		Naqada (NAQ)		Nepalese (NEP)	
Meas.	Value	N	Value	N	Value	N	Value	N	Value	N	Value	N	Value	N	Value	N	Value	N
GOL	182.5	46	179.4	58	181.7	12	181.9	13	185.5	10	183.2	26	183.6	13	181.4	403	171.6	55
BEB	134.8	47	130.5	57	138.1	12	134.9	13	138.8	5	134.2	26	126.2	11	132.6	388	129.9	55
AVH	111.6	41	109.7	55	111.4	10	113.2	9	114.3	3	117.8	18	117.7	13	116.7	363	113.0	56
SA	363.4	37	367.5	57	364.5	2	368.7	10	379.0	4	372.1	14	376.2	9	369.3	316	356.7	53
CAB	505.2	39	494.8	58	510.8	11	518.5	13	514.4	5	510.9	19	492.6	10	504.5	306	484.0	55
BFTB	91.5	45	90.2	58	93.0	11	94.3	11	94.4	7	93.5	22	90.2	14	89.7	385	89.2	56
NPH	72.7	41	65.9	54	63.1	6	62.4	8	68.2	8	68.7	4	65.8	9	64.8	245	64.0	51
NH	52.5	42	46.9	54	48.1	3	47.6	10	49.2	11	53.3	4	47.8	12	47.3	256	46.8	56
NB	25.0	43	24.2	54	24.0	5	25.9	10	24.8	10	27.1	5	23.2	11	24.6	249	24.8	56
OH	34.9	43	31.7	55	34.9	3	32.1	10	34.1	11	34.1	11	33.2	13	32.2	261	32.4	56
OB	39.3	42	38.0	53	39.1	3	40.4	11	40.8	12	39.2	10	38.4	13	40.9	260	38.5	55
BZB	125.8	40	120.1	45	126.2	4	127.5	6	126.8	3	117.6	8	116.8	7	121.6	135	120.5	49
IPL	48.9	42	45.5	51	44.1	3	43.0	6	46.8	8	40.5	5	46.4	8	52.1	219	43.4	50
IPB	41.6	36	37.1	47	39.8	3	37.5	3	37.2	10	35.9	5	38.6	8	38.5	221	39.2	50

	Harappan Phase (R37A)		Harappan Phase (R37C)		Sedment (SED)		Tell al - Judiadah (TEL)		Tepe Hissar II (TH2)		Tepe Hissar III (TH3)		Tibetans (TIB)		Timargarha (TMG)		Veddahs (VED)	
Meas.	Value	N	Value	N	Value	N	Value	N	Value	N	Value	N	Value	N	Value	N	Value	N
GOL	183.7	28	181.1	20	177.4	70	171.4	19	183.5	16	183.9	138	170.3	25	185.2	19	175.7	65
BEB	132.6	27	128.5	18	135.9	70	142.0	19	132.1	16	133.0	137	136.0	23	131.5	19	124.7	68
AVH	113.4	27	111.0	15	112.9	69	112.5	19	114.9	16	113.4	133	113.2	23	116.2	19	109.0	47
SA	371.8	23	373.0	17	365.4	63	358.8	11	370.7	16	372.6	135	356.7	25	372.5	15	351.1	39
CAB	512.4	24	505.1	12	501.1	70	499.6	18	507.9	16	506.9	137	489.4	23	511.6	19	486.1	65
BFTB	94.1	29	91.9	22	88.9	70	95.4	19	93.0	16	93.9	138	87.1	24	92.7	17	90.4	65
NPH	67.7	27	65.8	20	69.3	67	63.2	11	69.0	16	67.9	134	65.5	24	68.4	15	58.5	58
NH	50.1	30	46.9	22	50.2	67	48.8	10	49.4	16	49.2	133	48.8	25	49.1	16	41.8	55
NB	25.8	29	24.4	23	24.0	68	23.3	10	24.4	16	24.7	128	25.9	25	22.9	15	23.7	57
OH	34.2	31	32.7	23	33.1	66	32.9	14	32.6	16	31.9	134	33.5	25	33.2	15	32.2	60
OB	41.8	31	38.7	20	38.2	63	38.8	11	39.9	13	40.4	128	39.3	23	40.8	14	37.9	60
BZB	128.6	14	126.9	6	122.3	54	128.8	10	120.7	14	123.8	121	123.4	22	127.7	8	119.3	62
IPL	46.4	22	47.6	22	45.1	60	42.3	9	46.9	14	46.5	121	43.6	23	44.9	4	50.3	47
IPB	39.9	22	34.0	24	39.0	55	38.1	9	39.1	14	39.1	120	40.7	23	38.4	5	46.6	45

Table 11.14. Principal Components Analysis of Craniometric Variation among South Asians

Cranial Measurement	Principal Component One	Two	Three
Glabello-Occipital Length (GOL)	0.708	0.647	-0.105
Bieuryonic Breadth (BEB)	0.693	-0.583	0.242
Auricular Height (AVH)	0.578	0.320	-0.317
Sagittal Arc (SA)	0.864	0.433	-0.055
Circumference Above Browridges (CAB)	0.857	0.062	-0.119
Bifrontotemporale Breadth (BFTB)	0.660	0.293	-0.151
Nasion-Prosthion Height (NPH)	0.835	0.084	0.206
Nasal Height (NH)	0.877	-0.227	0.017
Nasal Breadth (NB)	0.129	-0.889	0.060
Orbital Height (OH)	0.622	0.132	0.674
Orbital Breadth (OB)	0.923	-0.129	0.064
Bizygomatic Breadth (BZB)	0.752	-0.297	0.095
Internal Palatal Length (IPL)	-0.374	0.680	0.510
Internal Palatal Breadth (IPB)	-0.891	0.113	0.242
Eigenvalue	7.452	2.584	2.169
Percentage of Variance Explained	53.228	18.456	15.495
Total Variance Explained		87.179	

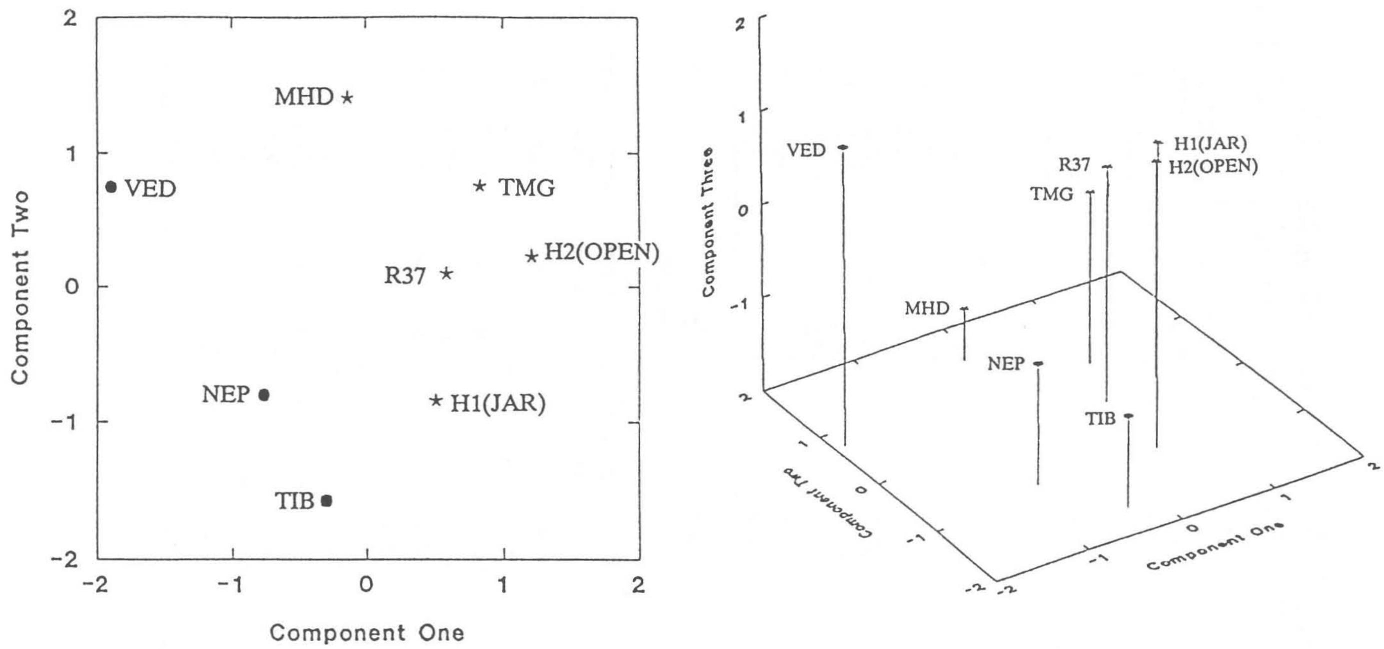

Figure 11.10. Two and three dimensional ordination of principal component scores derived from craniometric variation among South Asians.

the sole exception of Mohenjo-daro, Indus Valley samples (stars) stand apart from other South Asian sites (circles) with high scores along component one. In contrast to cluster analysis, principal components suggest that individuals from the Harappan phase cemetery bear slightly closer affinity to Late Harappan (Cemetery H) earth burials (H2) than to individuals from Timargarha. Component two indicates that individuals from jar burials at Cemetery H (H1) and Mohenjo-daro are only peripherally associated with the other Pakistani sites and are clearly very different from one another. Addition of component three emphasizes the similarities among all Indus Valley sites except Mohenjo-daro.

In the third phase of this craniometric analysis, nine prehistoric samples from Egypt, Anatolia,

Mesopotamia, and the Iranian Plateau were contrasted with eight South Asian samples to examine population relationships from a regional perspective. To provide maximum comparability, the same fourteen variables used to contrast South Asians were employed. Samples were divided by sex, and the adequacy of these variables for drawing distinctions across all samples was tested with analysis of variance (Table 11.15). With fourteen significant differences among both males and females (14/14 = 100.0%), analysis of variance confirms that these craniometric variables may be used to examine differences among these samples.

Group mean values were calculated for each variable in each sample according to the method described for South Asian samples above and are listed in Table 11.13. These values were submitted to cluster analysis and dendrograms were constructed in euclidean space with Ward's minimum variance technique. Cluster analysis identifies three main groups (Figure 11.11). Tibetans, Nepalese, and Veddahs share relatively close affinities to one another and are quite distinct from all other samples. The rest of the samples fall into two groups. The first is composed of nine samples and includes all prehistoric Pakistani sites (except Mohenjo-daro), the two samples from Tepe Hissar, and samples from Chatal Hüyük and Kish. The second group is composed of five samples and includes all Egyptian sites, Tell al-Judiadah, and Mohenjo-daro. Individuals from the Harappan phase cemetery bear closest affinities to Timargarha, followed by the two samples from Tepe Hissar. Viewed in the context of these Near Eastern sites, cluster analysis suggests that affinities between the Harappan phase burials and the two Late Harappan samples from Cemetery H are not close.

Principal components analysis results in three components that combine to explain 67.8% of the total variance (Table 11.16). The first component draws the same distinction between measurements of the neurocranium and face with those of the palate found among South Asian samples. Again, neurocranial and facial measurements receive high loadings and palatal measurements low loadings. Thus, as among South Asian samples alone, high scorers along the first component reflect samples that possess relatively large neural and facial cranial measurements in combination with rather small palatal measurements. The second component draws a distinction between neurocranial, facial, and palatal breadth measurements and their paired measurements of height and length. Cranial breadth, bizygomatic breadth, bifrontotemporale breadth, and internal palatal breadth all possess higher loadings than cranial length, sagittal arc, auricular height, nasion-prosthion height, and internal palatal length. Thus, high scorers for component two feature relatively broad and low cranial vaults and faces, coupled with a wide palate. The distinction drawn by the third component is between measurements of the cranial vault and those of the face, exclusive of the palate. With the exceptions of auricular height and orbital breadth, vault measurements possess higher loadings than those of the face. As a result, high scorers for component three feature relatively large but low cranial vaults with large faces. Conversely, low scorers along component three are marked by relatively small but high cranial vaults with rather small faces.

Ordination of principal component scores into two and three dimensions are presented in Figure 11.12. Sites from the Indus Valley are represented by stars, other South Asian samples by squares, Egyptian sites

Table 11.15. Analysis of Variance of Cranial Measurements among All Groups by Sex

	Females			Males		
Craniometric Measurement	F	p	N	F	p	N
Glabello-Occipital Length (GOL)	6.515	0.000*	408	13.613	0.000*	597
Bieuryonic Breadth (BEB)	7.236	0.000*	395	14.800	0.000*	587
Auricular Height (AVH)	2.095	0.008*	369	6.767	0.000*	548
Sagittal Arc (SA)	3.381	0.000*	323	6.100	0.000*	506
Circumference Above Browridges (CAB)	6.367	0.000*	347	11.827	0.000*	539
Bifrontotemporale Breadth (BFTB)	5.641	0.000*	396	4.892	0.000*	582
Nasio-Prosthion Height (NPH)	7.043	0.000*	301	13.113	0.000*	480
Nasal Height (NH)	4.965	0.000*	315	11.547	0.000*	489
Nasal Breadth (NB)	3.018	0.000*	313	2.661	0.000*	483
Orbital Height (OH)	3.998	0.000*	323	3.256	0.000*	506
Orbital Breadth (OB)	12.020	0.000*	316	13.954	0.000*	500
Bizygomatic Breadth (BZB)	3.440	0.000*	203	5.913	0.000*	406
Internal Palatal Length (IPL)	11.903	0.000*	264	25.575	0.000*	435
Internal Palatal Breadth (IPB)	3.304	0.000*	259	6.876	0.000*	426

* = $p < 0.05$

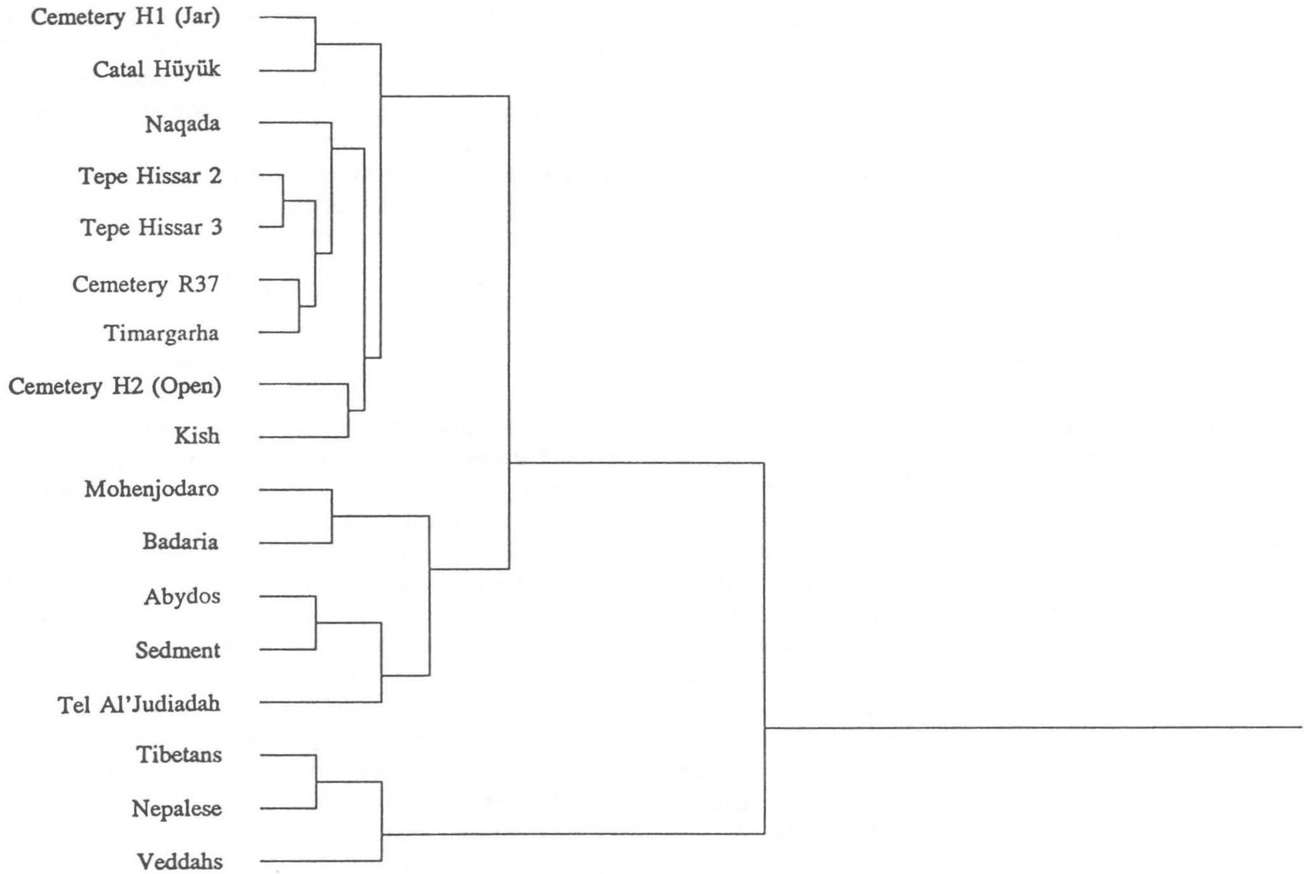

Figure 11.11. Cluster analysis of craniometric variation among all groups.

Table 11.16. Principal Components Analysis of Craniometric Variation among All Groups

	Principal Component		
Cranial Measurement	One	Two	Three
Glabello-Occipital Length (GOL)	0.708	-0.568	0.194
Bieuryonic Breadth (BEB)	0.401	0.736	0.080
Auricular Height (AVH)	0.557	-0.402	-0.397
Sagittal Arc (SA)	0.813	-0.478	0.001
Circumference Above Browridges (CAB)	0.889	0.017	0.333
Bifrontotemporale Breadth (BFTB)	0.610	0.211	0.503
Nasion-Prosthion Height (NPH)	0.626	-0.114	-0.405
Nasal Height (NH)	0.773	0.225	-0.482
Nasal Breadth (NB)	0.347	0.182	-0.397
Orbital Height (OH)	0.447	0.315	-0.185
Orbital Breadth (OB)	0.722	-0.193	0.397
Bizygomatic Breadth (BZB)	0.430	0.498	0.622
Internal Palatal Length (IPL)	-0.244	-0.636	0.390
Internal Palatal Breadth (IPB)	-0.729	-0.054	0.227
Eigenvalue	5.405	2.188	1.903
Percentage of Variance Explained	38.605	15.626	13.593
Total Variance Explained		67.824	

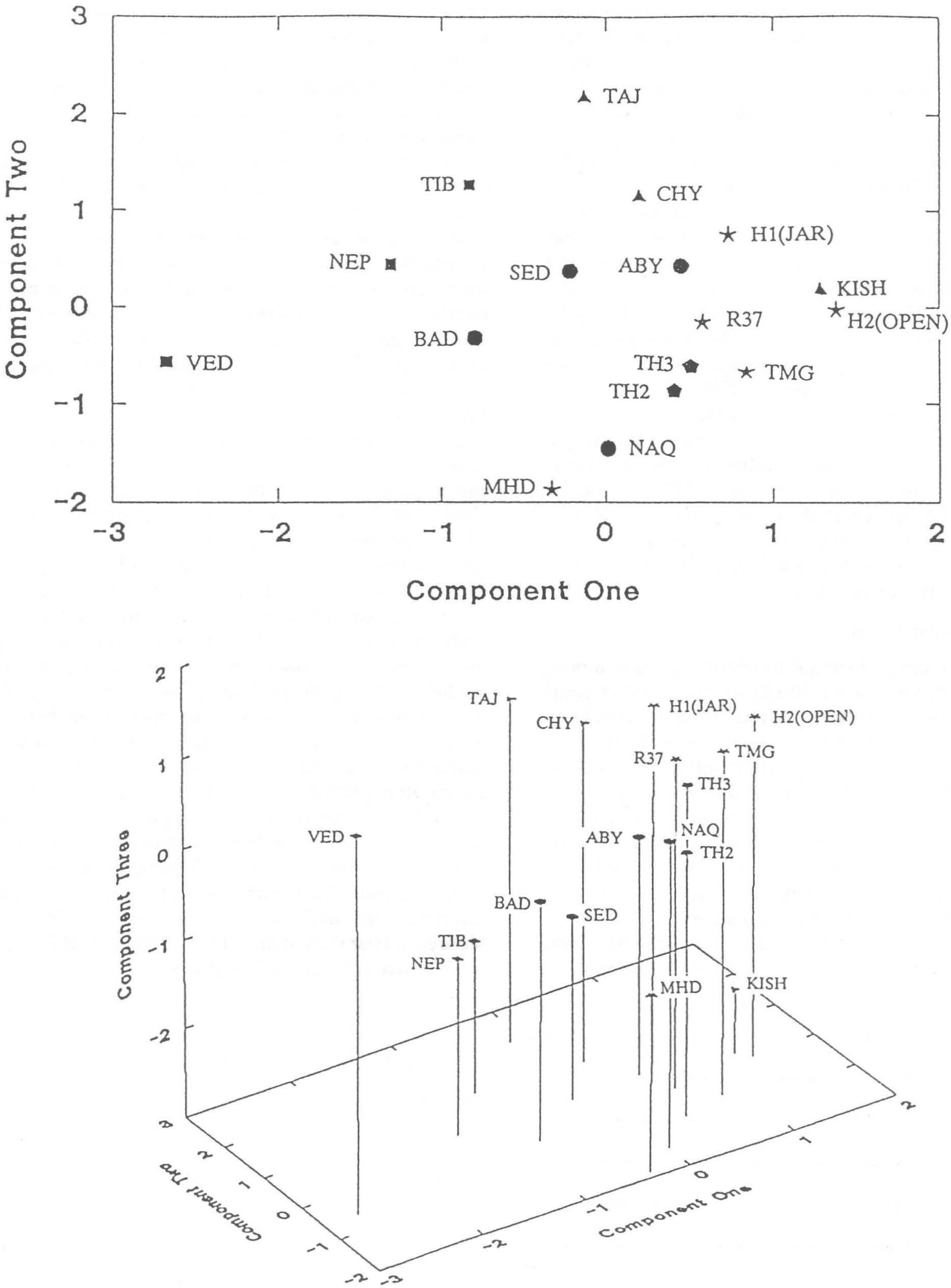

Figure 11.12. Ordination of principal component scores derived from craniometric variation among all groups.

by circles, Anatolian Plateau sites by triangles, and sites of the Iranian Plateau by pentagons. High scores along component one separate all Indus Valley sites except Mohenjo-daro away from all other samples except Abydos, Kish, and the two samples from Tepe Hissar. Component two separates Anatolian Plateau sites with high scores, and samples from Naqada and Mohenjo-daro with low scores, from all other samples. Although ordination of the first two components suggests that individuals from the Harappan phase cemetery possess equally close affinities to samples from Abydos and Tepe Hissar III as to Timargarha, addition of the third component reveals that affinities between the Harappan phase cemetery and Abydos are not close, while affinities to Timargarha are slightly closer than those with Tepe Hissar III. Lower (earth) burials at Cemetery H (H2) possess closest affinities to the Harappan phase cemetery and Timargarha, but upper (jar) burials from Cemetery H (H1) exhibit equally close affinities to these samples as to the Anatolian sample from Chatal Hüyük. Located in the center foreground, Mohenjo-daro is strongly separated from all other Indus Valley samples and possesses no close affinities to any of the other samples included in this ordination.

Dental Non-metrics

The frequency of dental morphology traits among Harappan phase (R37) individuals and six other South Asian prehistoric samples are presented in Table 11.17. Contingency chi-square analysis (Table 11.18) indicates that five of the sixteen traits reflect a significant degree of heterogeneity. Since this number of significant differences is nearly three times the number of significant differences expected from chance ($p < 0.05$; $5/16 = 31.2\%$), these traits may be accepted as adequate data for identifying patterns of identity among these South Asian dental series.

Arcsine transformed trait frequencies were submitted to cluster analysis, and dendrograms were constructed in euclidean space with Ward's minimum variance technique (Figure 11.13). Cluster analysis indicates that these South Asian samples fall into two main groups. The first includes mesolithic Ganga Valley, neolithic Mehrgarh, and Late Bronze Age Inamgaon. The second includes Sarai Khola, Timargarha, chalcolithic Mehrgarh, and the Harappan phase sample from Harappa (R37). Two important points may be noted from cluster analysis. First, the two samples from Mehrgarh share widely different phenetic associations, with neolithic individuals as members of group one and chalcolithic individuals members of group two. Second, there is a nearly complete division of sites between those of peninsular India in group one and of the Indus Valley sites in group two. The neolithic inhabitants of Mehrgarh, as members of group one, represent the sole exception to this division.

Multidimensional scaling of standardized mean measure of divergence distances (Table 11.19) provides confirmation for the pattern of affinities identified by cluster analysis for members of group one (Figure 11.14). Samples from Pakistan are represented as stars and samples from peninsular India as circles. Mesolithic individuals from the Ganga Valley, located on the right side of this ordination, represent an isolate with no close affinities to any of the other series and only peripheral association with Inamgaon and neolithic Mehrgarh. Perhaps most dramatically, this ordination confirms the lack of association between neolithic and chalcolithic inhabitants of Mehrgarh. Rather than possessing closest affinities to one another, the result expected from *in situ* continuity, dimension one indicates that these two samples from Mehrgarh represent the most strongly separated of the seven series considered. Instead of exhibiting closest affinities to chalcolithic Mehrgarh, multidimensional scaling confirms that individuals from neolithic levels at Mehrgarh bear closest affinities to individuals from the Late Bronze Age site of Inamgaon.

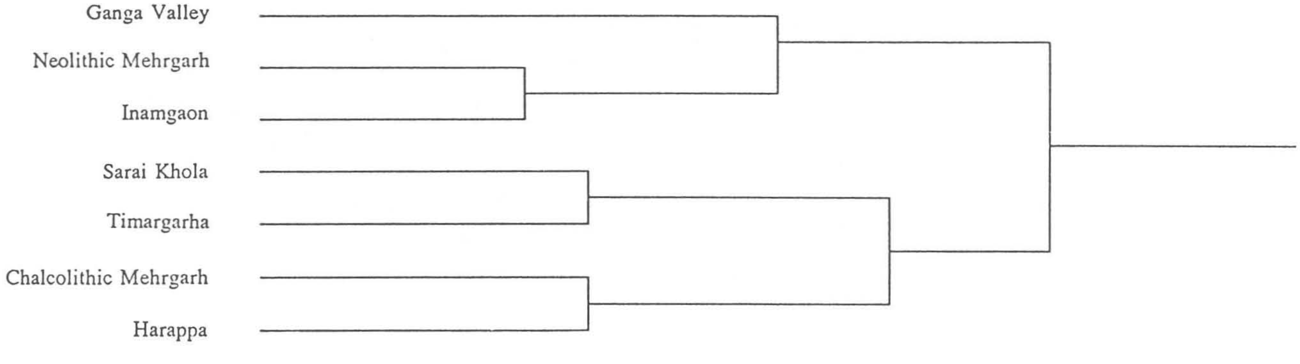

Figure 11.13. Cluster analysis of dental non-metric trait variation among South Asians.

Table 11.17. Frequencies of dental non-metric traits among prehistoric South Asians

		Harappa (R37)			Chalcolithic Mehrgarh			Neolithic Mehrgarh			Inamgaon			Sarai Khola			Timargarha			Ganga Valley		
Trait	Tooth	p	n	f	p	n	f	p	n	f	p	n	f	p	n	f	p	n	f	p	n	f
SHOV	UI1	9	15	0.600	21	25	0.840	25	28	0.893	22	24	0.917	3	9	0.333	5	7	0.714	4	6	0.667
SHOV	UI2	10	16	0.625	21	24	0.875	31	37	0.838	13	19	0.684	2	9	0.222	4	7	0.571	5	7	0.714
MLR	UI1	8	12	0.667	14	25	0.560	15	26	0.577	14	25	0.560	2	11	0.182	3	8	0.375	2	6	0.333
MLR	UI2	6	13	0.462	7	24	0.292	2	29	0.069	1	20	0.050	0	9	0.000	0	7	0.000	2	7	0.286
MIG	UI1	1	13	0.077	2	21	0.095	0	27	0.000	0	25	0.000	1	10	0.100	1	8	0.125	2	6	0.333
HYPO	UM1	16	16	1.000	22	22	1.000	35	42	0.833	27	41	0.659	15	21	0.714	17	22	0.773	9	9	1.000
CARA	UM1	4	9	0.444	11	18	0.611	7	27	0.259	13	40	0.325	5	13	0.385	9	18	0.500	0	8	0.000
MTCNLE	UM1	6	13	0.462	5	19	0.263	7	28	0.250	6	41	0.146	3	13	0.231	4	19	0.211	2	6	0.333
MTCNLE	UM2	4	16	0.250	6	18	0.333	10	25	0.400	3	20	0.150	2	12	0.167	0	13	0.000	1	7	0.143
MTCNLE	UM3	4	13	0.308	0	11	0.000	8	19	0.421	1	6	0.167	3	11	0.273	2	10	0.200	4	8	0.500
ENTO	LM3	0	18	0.000	1	16	0.063	1	34	0.029	1	12	0.083	2	14	0.143	1	6	0.167	1	7	0.143
CUSPN	LM1	17	20	0.850	20	23	0.870	4	43	0.093	7	39	0.179	6	15	0.400	4	6	0.667	2	8	0.250
CUSPN	LM3	10	20	0.500	10	17	0.588	12	38	0.316	6	11	0.545	9	14	0.643	4	6	0.667	1	7	0.143
Y-GROOVE	LM1	15	17	0.882	15	21	0.714	23	25	0.920	32	35	0.914	5	7	0.714	12	17	0.706	4	5	0.800
Y-GROOVE	LM2	3	31	0.097	6	22	0.273	12	37	0.324	7	24	0.292	5	14	0.357	3	18	0.167	4	8	0.500
Y-GROOVE	LM3	2	18	0.111	1	16	0.063	3	27	0.111	1	10	0.100	1	12	0.083	1	6	0.167	2	7	0.286

Table 11.18. Contingency Chi-Square Analysis of Dental Non-Metric Traits among Prehistoric South Asians

Dental Trait	Tooth	X2	p	df
Shoveling (SHOV)	UI1	21.033	0.002*	6
Shoveling (SHOV)	UI2	18.178	0.006*	6
Median Lingual Ridge (MLR)	UI1	8.216	0.223	6
Median Lingual Ridge (MLR)	UI2	18.843	0.004*	6
Mar. Inter. Grooves (MIG)	UI1	11.976	0.063	6
Hypocone Development (HYPO)	UM1	19.095	0.004*	6
Carabelli's Trait (CARA)	UM1	12.507	0.052	6
Metaconule (MTCNLE)	UM1	5.963	0.427	6
Metaconule (MTCNLE)	UM2	10.236	0.115	6
Metaconule (MTCNLE)	UM3	8.785	0.186	6
Entoconulid (ENTO)	LM3	4.932	0.553	6
Cusp Number (CUSPN)	LM1	16.849	0.010*	6
Cusp Number (CUSPN)	LM3	9.332	0.156	6
Y Groove Pattern (Y-GROOVE)	LM1	8.233	0.222	6
Y Groove Pattern (Y-GROOVE)	LM2	9.135	0.166	6
Y Groove Pattern (Y-GROOVE)	LM3	2.751	0.839	6

* = p< 0.05

Table 11.19. Mean Measure of Distance Scores Derived from Dental Non-Metric Variation among Prehistoric South Asians

	Ganga Valley	Neolithic Mehrgarh	Chalcolithic Mehrgarh	Harappa (R37)	Inamgaon	Sarai Khola
Ganga Valley						
Neolithic Mehrgarh	-0.014 0.041 -0.329					
Chalcolithic Mehrgarh	0.158 0.141 1.125	0.189 0.154 1.229				
Harappa (R37)	0.067 0.092 0.735	0.175 0.148 1.182	-0.018 0.047 -0.378			
Inamgaon	0.026 0.057 0.455	-0.026 0.057 -0.453	0.122 0.123 0.987	0.139 0.132 1.055		
Sarai Khola	0.023 0.054 0.430	0.172 0.147 1.174	0.183 0.151 1.209	0.117 0.121 0.968	0.059 0.086 0.686	
Timargarha	0.002 0.016 0.124	0.099 0.111 0.891	-0.025 0.056 -0.448	-0.022 0.052 -0.417	-0.050 0.079 -0.635	-0.088 0.105 -0.839

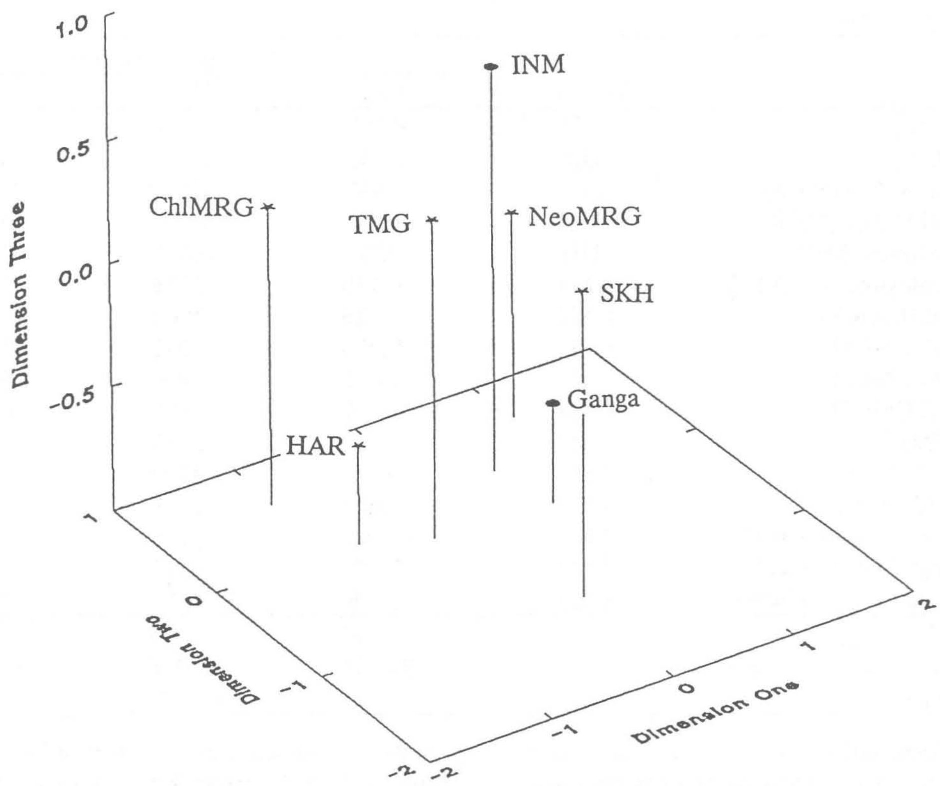

Figure 11.14. Multidimensionally scaled ordination of dental non-metric trait variation among South Asians.

However, when the pattern of affinities identified by cluster analysis among members of group two are considered, multidimensional scaling presents a different interpretation of these relationships. Harappan phase individuals do not possess closer affinities to chalcolithic Mehrgarh than to any other samples; rather this ordination reveals that Harappan phase individuals are equally similar to individuals from chalcolithic Mehrgarh as they are to individuals from post-Harappan Timargarha. Located intermediate between these latter two series in time and space (as well as in this ordination), Harappan phase individuals possess the pattern of affinities expected under conditions of prolonged biological continuity within the Indus Valley from early chalcolithic times (4500 BC) until the early post-Harappan period (800 BC). Identified as the sole occupants in the foreground of this ordination, individuals from Sarai Khola possess no close affinities to any other sample considered, but as expected from cluster analysis, of these other series, Sarai Khola bears closest affinities to Timargarha.

Principal components analysis of standardized arcsine transformed trait frequencies yields three components that combine to explain 82.3% of the total variance (Table 11.20). High scorers along the first component reflect samples that possess relatively high frequencies of marginal interruption grooves on UI2, Carabelli's Trait, and retention of the hypoconulid on all mandibular molars coupled with relatively low frequencies of incisor shoveling, the metaconule, and the Y-groove molar pattern. Similarly, high scorers for component two feature relatively high incidences of incisor shoveling, median lingual ridge development, and maxillary molars which feature Carabelli's Trait, the metaconule and full expression of the hypocone, and retention of the hypoconulid on LM1 combined with low frequencies of the metaconule on UM3, the entoconulid on LM3, and the Y-groove pattern on all mandibular molars. High scorers for component three are marked by relatively high frequencies of median lingual ridge development on UI2, marginal interruption grooves on UI1, full expression of the hypocone and the presence on the metaconule on UM1, and the Y-groove pattern on all mandibular molars accompanied by low frequencies of shoveling on UI1, Carabelli's Trait on UM1, and retention of the hypoconulid among mandibular molars.

Ordination of group component scores for the first three principal components (Figure 11.15) provides strong confirmation of results obtained from cluster

Table 11.20. Principal Components Analysis of Dental Non-Metric Variation among Prehistoric South Asians

Dental Trait	Tooth	Principal Component		
		One	Two	Three
Shoveling (SHOV)	UI1	-0.795	0.080	-0.288
Shoveling (SHOV)	UI2	-0.693	0.434	0.067
Median Lingual Ridge (MLR)	UI1	-0.681	0.619	-0.072
Median Lingual Ridge (MLR)	UI2	0.306	0.771	0.430
Marg. Inter. Grooves (MIG)	UI1	0.776	-0.067	0.565
Hypocone Development (HYPO)	UM1	0.130	0.756	0.577
Carabelli's Trait (CARA)	UM1	0.426	0.631	-0.606
Metaconule (MTCNLE)	UM1	0.274	0.592	0.699
Metaconule (MTCNLE)	UM2	-0.663	0.465	0.230
Metaconule (MTCNLE)	UM3	-0.338	-0.451	0.739
Entoconulid (ENTO)	LM3	0.705	-0.615	-0.123
Cusp Number (CUSPN)	LM1	0.672	0.733	-0.014
Cusp Number (CUSPN)	LM3	0.642	0.179	-0.722
Y Groove Pattern (Y-GROOVE)	LM1	-0.842	-0.121	-0.006
Y Groove Pattern (Y-GROOVE)	LM2	-0.175	-0.646	0.195
Y Groove Pattern (Y-GROOVE)	LM3	0.306	-0.522	0.588
Eigenvalue		5.294	4.569	3.307
Percentage of Variance Explained		33.087	28.557	20.666
Total Variance Explained			82.310	

analysis. Symbol designations are the same as those for Figure 11.14. Thus, three sample groups and one isolate are identified. Individuals from the Harappan phase cemetery at Harappa possess closest affinities to chalcolithic inhabitants of Mehrgarh. The two post-Harappan northern Pakistani samples from Sarai Khola and Timargarha bear closest affinities to one another, and neolithic inhabitants of Mehrgarh are most similar to the Late Bronze age sample from Inamgaon. Mesolithic Ganga Valley inhabitants represent an isolate that possesses no close affinities to any of the other samples included in this analysis.

Cranial Non-metrics

Biological affinities of Harappan phase R37C individuals are placed in broad regional perspective by contrasting them with ten samples from Egypt, the Near East, and South Asia. The frequency of cranial non-metric traits among these eleven cranial series are presented in Table 11.21. Contingency chi-square analysis (Table 11.22) indicates that eleven of these traits reflect a significant degree of heterogeneity. Since this number of significant differences is greater than twelve times the number of significant differences expected from chance ($p < 0.05$; 11/18 = 61.1%), these traits may be accepted as adequate data for identifying patterns of affinity among them.

Cluster analysis of arcsine transformed trait frequencies indicate that all South Asian samples do not cluster together (Figure 11.16). In fact, two major groups may be identified. The first includes Harappan phase (R37) individuals from Harappa and all modern and ancient Near Eastern populations, except Jordanian Bedouins. The second group includes all South Asian samples (except Harappan phase individuals), modern Burmese, and ancient Egyptians. What is clear from cluster analysis is that skeletons recovered from the Harappan phase cemetery represent a South Asian sample that possesses a very different set of phenetic relationships than those possessed by Sarai Khola, Mahadaha, or modern Punjabis.

Multidimensional scaling of standardized mean measure of divergence distances (Table 11.23) indicates that three sample groups and one isolate are present (Figure 11.17). Indus Valley samples are represented by stars, Near Eastern and Anatolian samples as triangles, other South Asian samples by squares, and Egyptians by circles. Harappan phase individuals (R37) along with the two Palestinian samples form one group, southern Anatolian sites form another group, and the rest of the samples form a third group. While Kamid el-Loz and Lidar bear closer affinities to one another than to any of the other samples included in this analysis, Kamid el-Loz is more closely associated with Harappan phase individuals and Palestinians than is Lidar. This last sample appears to be intermediate between the smaller Harappo-Palestinian group and the larger South Asian group, with closest phenetic affinities to Sarai Khola. As indicated from cluster analysis, Jordanian Bedouins exhibit no close affinities to any of the other samples.

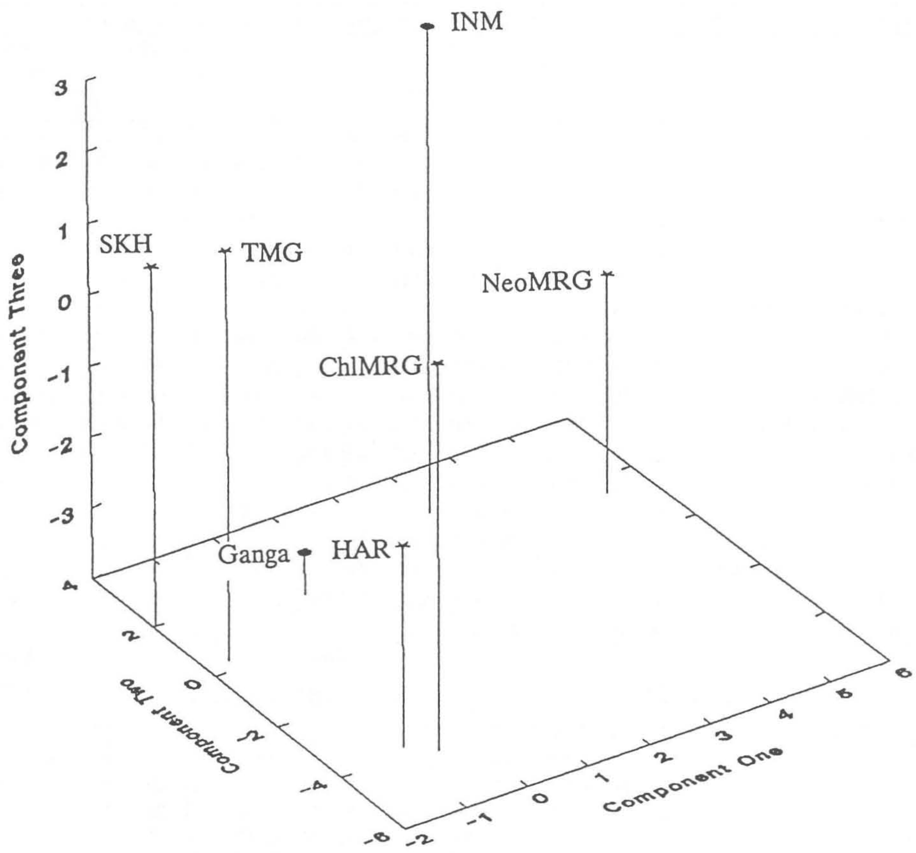

Figure 11.15. Ordination of principal component scores derived from dental non-metric trait variation among South Asians.

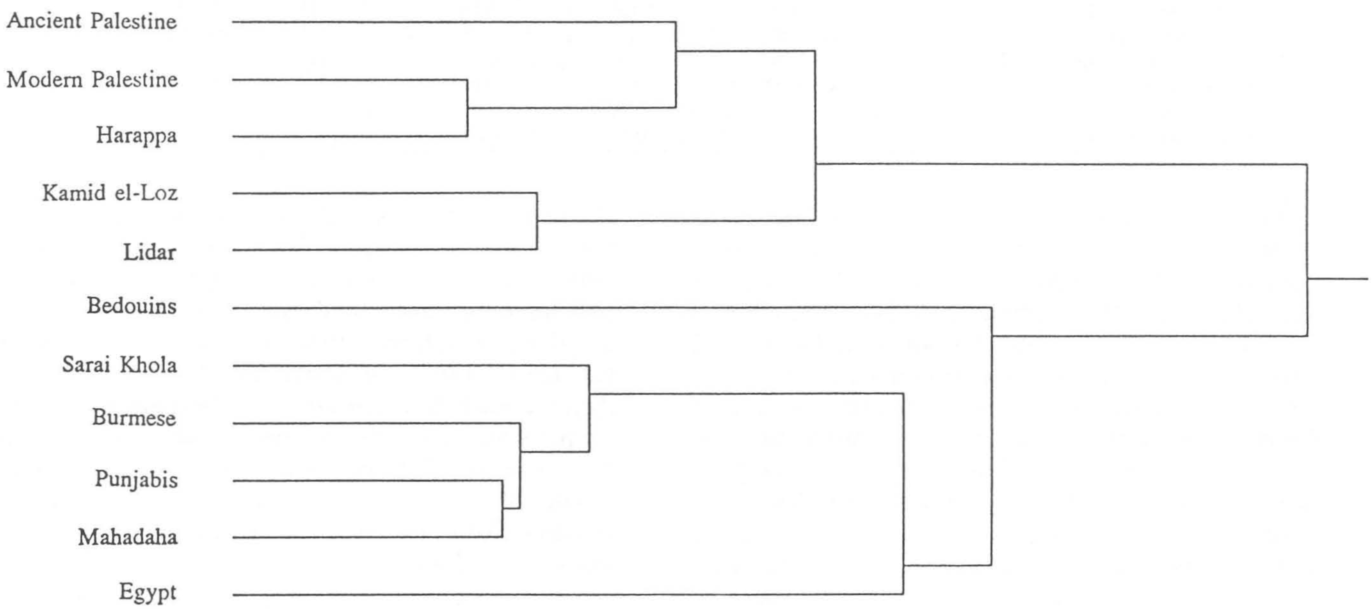

Figure 11.16. Cluster analysis of cranial non-metric trait variation among all groups.

Table 11.21. Frequencies of cranial non-metric traits among all groups (P=no. present; N=sample size; F=frequency).

	Harappa			Ancient Egypt			Ancient Palestine			Modern Palestine			Modern Punjab			Modern Burma		
Cranial Trait	*P*	*N*	*F*	*P*	*N*	*F*	*P*	*N*	*F*	*P*	*N*	*F*	*P*	*N*	*F*	*P*	*N*	*F*
Ossicle at the Lambda (OLAM)	1	16	0.063	37	250	0.148	6	54	0.111	4	18	0.222	11	53	0.208	7	51	0.137
Lambdoidal Ossicle (LOP)	4	35	0.114	161	499	0.323	32	107	0.299	12	36	0.333	34	106	0.321	30	102	0.294
Parietal Foramen (PARF)	8	37	0.216	221	500	0.442	38	108	0.352	8	36	0.222	53	106	0.500	51	102	0.500
Metopic Suture (METOP)	0	21	0.000	18	250	0.072	4	54	0.074	1	18	0.056	3	53	0.057	0	51	0.000
Coronal Ossicle (COROSS)	2	31	0.065	13	498	0.026	4	108	0.037	0	34	0.000	2	106	0.019	1	102	0.010
Epipteric Bone (EPIB)	2	27	0.074	70	487	0.144	10	105	0.095	2	31	0.065	18	106	0.170	15	102	0.147
Fronto-Temporal Articulation (FTART)	1	24	0.042	10	489	0.021	1	106	0.009	3	31	0.097	2	106	0.019	3	102	0.029
Parietal Notch Bone (PNB)	1	37	0.027	37	498	0.074	3	108	0.028	4	36	0.111	8	106	0.076	8	102	0.078
Ossicle at Asterion (ASTOSS)	3	37	0.081	64	497	0.129	7	108	0.065	3	36	0.083	9	106	0.085	10	102	0.098
Foramen of Huschke (FORHUS)	3	33	0.091	69	494	0.140	18	95	0.190	2	33	0.061	24	106	0.226	25	102	0.245
Mastoid Foramen Ex-Sutural (MFEX)	6	32	0.188	190	496	0.383	25	108	0.232	12	36	0.333	49	106	0.462	47	102	0.461
Mastoid Foramen Absent (MFA)	4	33	0.121	62	496	0.125	42	108	0.389	7	36	0.194	19	106	0.179	8	102	0.078
Precondylar Tubercle (PRETUB)	1	35	0.029	34	496	0.069	6	106	0.057	0	32	0.000	6	106	0.057	10	102	0.098
Bifid Hypoglossal Canal (BHC)	1	34	0.029	82	494	0.166	7	100	0.070	3	36	0.083	19	106	0.179	10	102	0.098
Acc. Lesser Palatine Foramen (ALPF)	7	23	0.304	228	469	0.486	12	91	0.132	7	30	0.233	51	106	0.481	31	97	0.320
Zygomatico-Facial Foramen Absent (ZFFA)	14	28	0.500	94	478	0.197	30	100	0.300	13	34	0.382	29	104	0.279	18	101	0.178
Frontal Foramen (FRFOR)	6	35	0.171	161	500	0.322	20	108	0.185	7	34	0.206	34	106	0.321	33	102	0.324
Acc. Infraorbital Foramen (AIOF)	0	24	0.000	23	489	0.047	3	102	0.029	2	31	0.065	7	105	0.067	7	93	0.075

	Mahadaha			Lidar			Kamid el-Loz			Sarai Khola			Modern Bedouin		
Cranial Trait	*P*	*N*	*F*	*P*	*N*	*F*	*P*	*N*	*F*	*P*	*N*	*F*	*P*	*N*	*F*
Ossicle at the Lambda (OLAM)	0	9	0.000	5	25	0.200	4	38	0.105	5	24	0.208	7	25	0.280
Lambdoidal Ossicle (LOP)	1	17	0.059	10	20	0.500	18	37	0.487	9	21	0.429	16	49	0.327
Parietal Foramen (PARF)	8	20	0.400	15	39	0.385	27	69	0.391	24	48	0.500	31	50	0.620
Metopic Suture (METOP)	0	9	0.000	5	20	0.250	3	34	0.088	1	22	0.046	4	25	0.160
Coronal Ossicle (COROSS)	0	16	0.000	0	17	0.000	1	24	0.042	0	18	0.000	3	22	0.136
Epipteric Bone (EPIB)	2	15	0.133	0	13	0.000	4	20	0.200	3	22	0.136	6	40	0.150
Fronto-Temporal Articulation (FTART)	2	13	0.154	0	13	0.000	0	32	0.000	0	21	0.000	4	40	0.100
Parietal Notch Bone (PNB)	1	16	0.063	1	27	0.037	2	62	0.032	2	41	0.049	5	50	0.100
Ossicle at Asterion (ASTOSS)	0	17	0.000	6	34	0.177	5	62	0.081	3	36	0.083	7	51	0.137
Foramen of Huschke (FORHUS)	0	17	0.000	6	31	0.194	4	80	0.050	2	32	0.063	16	23	0.696
Mastoid Foramen Ex-Sutural (MFEX)	7	15	0.467	21	33	0.636	32	68	0.471	29	39	0.744	25	48	0.521
Mastoid Foramen Absent (MFA)	1	11	0.091	4	28	0.143	7	69	0.102	3	12	0.250	22	47	0.468
Precondylar Tubercle (PRETUB)	0	16	0.000	1	8	0.125	2	8	0.250	1	7	0.143	1	22	0.046
Bifid Hypoglossal Canal (BHC)	1	14	0.071	7	15	0.467	4	30	0.133	0	7	0.000	2	19	0.105
Acc. Lesser Palatine Foramen (ALPF)	6	10	0.600	1	8	0.125	0	23	0.000	1	4	0.250	20	40	0.500
Zygomatico-Facial Foramen Absent (ZFFA)	2	14	0.143	18	33	0.546	27	60	0.450	5	28	0.179	10	40	0.250
Frontal Foramen (FRFOR)	4	17	0.235	6	35	0.171	8	44	0.182	15	34	0.441	37	47	0.787
Acc. Infraorbital Foramen (AIOF)	1	11	0.091	0	22	0.000	1	29	0.035	0	21	0.000	5	40	0.125

Principal components analysis of standardized arcsine transformed trait frequencies results in three components that account for 69.2% of the total variance (Table 11.24). Component loadings indicate that high scorers along the first component reflect samples that possess relatively high frequencies of all non-metric variations except absence of zygomatico-facial foramen. High scorers for component two feature relatively high incidences of lambda ossicles, ossicles in the lambdoidal suture, metopism, ossicles in the coronal suture, fronto-temporal articulations at pterion, foramen of Huschke, ex-sutural or absent mastoid foramen, precondylar tubercles, absence of zygomatico-facial foramen, and accessory infraorbital foramen coupled with low frequencies of parietal foramen, epipteric bones, parietal notch bones, ossicles at asterion bifid hypoglossal canals, and accessory lesser palatine foramen. High scorers along component three are marked by relatively high frequencies of ossicles in the lambdoidal suture, metopism, ossicles at asterion, ex-sutural mastoid foramen, precondylar tubercles, bifid hypoglossal canals and absences of zygomatico-facial foramen accompanied by low frequencies of ossicles in the coronal suture, fronto-temporal articulations, parietal notch bones, foramen of Huschke, mastoid foramen absence, accessory lesser palatine foramen, frontal foramen, and accessory infra-orbital foramen.

Ordination of group component scores into three dimensions (Figure 11.18) confirms results obtained by cluster analysis and multidimensional scaling. Symbol designations are the same as for Figure 11.17. Once

Table 11.22. Contingency Chi-Square Analysis of Cranial Non-Metric Traits among All Groups

Non-metric Trait	χ^2	p	df
Ossicle at the Lambda (OLAM)	10.007	0.434	10
Lambdoidal Ossicle (LOP)	21.606	0.017*	10
Parietal Foramen (PARF)	29.388	0.001*	10
Metopic Suture (METOP)	19.767	0.032*	10
Coronal Ossicle (COROSS)	16.283	0.092	10
Epipteric Bone (EPIB)	7.892	0.639	10
Fronto-Temporal Articulation (FTART)	26.547	0.003*	10
Parietal Notch Bone (PNB)	8.217	0.608	10
Ossicle at Asterion (ASTOSS)	10.411	0.405	10
Foramen of Huschke (FORHUS)	76.148	0.000*	10
Mastoid Foramen Ex-Sutural (MFEX)	54.059	0.000*	10
Mastoid Foramen Absent (MFA)	83.382	0.000*	10
Precondylar Tubercle (PRETUB)	11.892	0.292	10
Bifid Hypoglossal Canal (BHC)	28.886	0.001*	10
Acc. Lesser Palatine Foramen (ALPF)	72.895	0.000*	10
Zygomatico-Facial Foramen Absent (ZFFA)	53.298	0.000*	10
Frontal Foramen (FRFOR)	72.727	0.000*	10
Acc. Infraorbital Foramen (AIOF)	11.643	0.310	10

* = $p < 0.05$

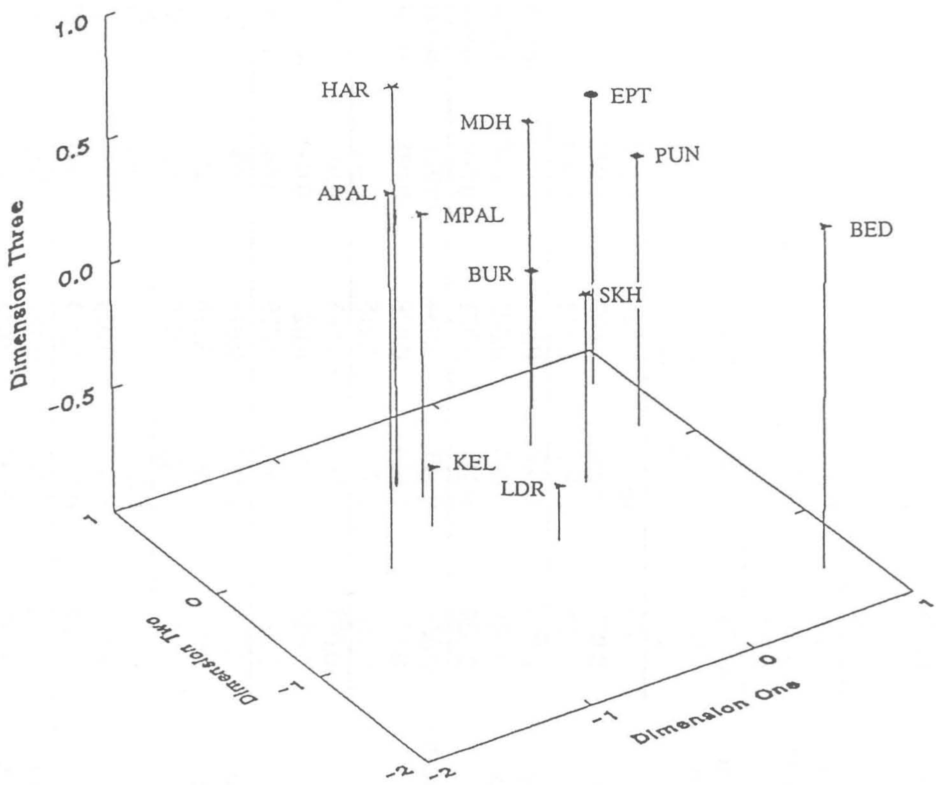

Figure 11.17. Multidimensionally scaled ordination of cranial non-metric trait variation among all groups.

Table 11.23. Mean Measure of Distance Scores Derived from Cranial Non-metric Variation among All Groups

	Harappa (R37)	Ancient Egypt	Ancient Palestine	Modern Palestine	Modern Punjab	Modern Burma	Mahadaha	Lidar	Kamid el-Loz	Sarai Khola
Harappa (R37)										
Ancient Egypt	0.034									
	0.013									
	2.682									
Ancient Palestine	0.004	0.052								
	0.015	0.004								
	0.249	11.711								
Modern Palestine	-0.033	0.012	-0.010							
	0.023	0.012	0.015							
	-1.448	1.057	-0.676							
Modern Punjab	0.039	-0.004	0.046	0.010						
	0.015	0.004	0.007	0.015						
	2.521	-0.961	6.414	0.683						
Modern Burma	0.036	0.002	0.040	0.012	-0.006					
	0.016	0.005	0.007	0.015	0.007					
	2.329	0.373	5.371	0.809	-0.817					
Mahadaha	-0.023	-0.345	0.034	-0.021	-0.030	-0.026				
	0.036	0.025	0.028	0.035	0.028	0.028				
	-0.631	-1.374	1.215	-0.589	-1.066	-0.935				
Lidar	0.075	0.063	0.065	0.014	0.038	0.056	0.082			
	0.030	0.020	0.023	0.030	0.023	0.023	0.043			
	2.454	3.092	2.839	0.460	1.670	2.443	1.935			
Kamid el-Loz	0.036	0.062	0.029	0.000	0.055	0.036	0.064	-0.015		
	0.023	0.014	0.016	0.023	0.016	0.016	0.035	0.032		
	1.533	4.612	1.825	0.015	3.463	2.226	1.803	-0.476		
Sarai Khola	0.067	-0.005	0.035	-0.001	-0.022	-0.025	-0.025	0.006	-0.006	
	0.036	0.027	0.029	0.035	0.029	0.029	0.048	0.045	0.038	
	1.870	-0.193	1.202	-0.030	-0.745	-0.847	-0.524	0.135	-0.170	
Modern Bedouin	0.242	0.141	0.186	0.189	0.093	0.120	0.152	0.192	0.256	0.079
	0.022	0.011	0.014	0.021	0.014	0.014	0.034	0.029	0.022	0.035
	11.121	12.711	13.451	8.998	6.710	8.573	4.445	6.584	11.446	2.263

Table 11.24. Principal Components Analysis of Cranial Non-Metric Variation among All Groups

	Principal Component		
Cranial Trait	One	Two	Three
Ossicle at the Lambda (OLAM)	0.788	0.288	0.099
Lambdoidal Ossicle (LOP)	0.271	0.104	0.826
Parietal Foramen (PARF)	0.817	-0.338	0.025
Metopic Suture (METOP)	0.359	0.570	0.528
Coronal Ossicle (COROSS)	0.282	0.747	-0.204
Epipteric Bone (EPIB)	0.446	-0.525	0.014
Fronto-Temporal Articulation (FTART)	0.278	0.645	-0.382
Parietal Notch Bone (PNB)	0.708	-0.249	-0.295
Ossicle at Asterion (ASTOSS)	0.472	-0.354	0.456
Foramen of Huschke (FORHUS)	0.700	0.306	-0.314
Mastoid Foramen Ex-Sutural (MFEX)	0.610	0.213	0.444
Mastoid Foramen Absent (MFA)	0.153	0.708	-0.310
Precondylar Tubercle (PRETUB)	0.108	0.398	0.610
Bifid Hypoglossal Canal (BHC)	0.376	-0.234	0.730
Acc. Lesser Palatine Foramen (ALPF)	0.486	-0.748	-0.154
Zygomatico-Facial Foramen Absent (ZFFA)	-0.266	0.811	0.293
Frontal Foramen (FRFOR)	0.905	0.004	-0.251
Acc. Infraorbital Foramen (AIOF)	0.690	0.248	-0.470
Eigenvalue	5.209	4.103	3.142
Percentage of Variance Explained	28.941	22.795	17.457
Total Variance Explained		69.193	

again, individuals from the Harappan phase cemetery and the two Palestinian samples form a group distinct from all other samples. The two Anatolian sites, Kamid el-Loz and Lidar, form a second group, and modern Punjabis, Burmese, and the mesolithic inhabitants of Mahadaha form a third group. Post-Harappan Sarai Khola is only peripherally associated with these latter samples. Principal components identify ancient Egyptians and Jordanian Bedouins as possessing no close phenetic associations with any of these Near East and South Asian samples.

Discussion

Agricultural Intensification

As stated in the introduction, perhaps the most significant adaptations faced by the third millennium population of Harappa were those incurred as a response to dietary changes involved with increased agricultural intensification. Examination of the dentition of Harappan phase individuals allows assessment of the biological impact of this cultural behavior from both proximate and ultimate evolutionary perspectives (Frayer and Wolpoff 1985).

Assessment of pathological conditions of the teeth and jaws provides insight into the short term impact of subsistence techniques on the immediate health of Harappan phase individuals. Individuals as the unit of biological adaptation must cope with the deleterious effects of increased sticky carbohydrate consumption and reduced masticatory stress that accompany increased reliance upon cultivated foodstuffs and increased sophistication of food preparatory techniques (Calcagno 1984; y'Edynak 1978, 1989; Greene 1972; Larsen 1983, 1984; Lukacs 1982; Turner 1979).

The first stage of the comparative analysis of dental pathology and agricultural intensification examined the suite of pathological afflictions experienced within the Indus Valley. Comparison of dental pathology affectation patterns at the Harappan phase cemetery to neolithic and chalcolithic skeletal series from Mehrgarh presented in Figure 11.5 demonstrate a progressive increase in all dental pathology conditions except calculus over time. Increased levels of hypoplasia are especially evident from these data, and such an increase in the frequency of hypoplasia with increased reliance upon cultivated foodstuffs has been reported by other workers from North and South America, Africa, Europe, and the Near East (Cohen and Armelagos 1984; Goodman and Rose 1990). This progressive decline in dental health within the Indus Valley from neolithic levels at Mehrgarh to the full urban phase of the Harappan Civilization accords well with expectations of the proximate effects of increasing reliance upon agriculture.

The suite of pathological conditions experienced by the individuals of the Harappan phase cemetery at

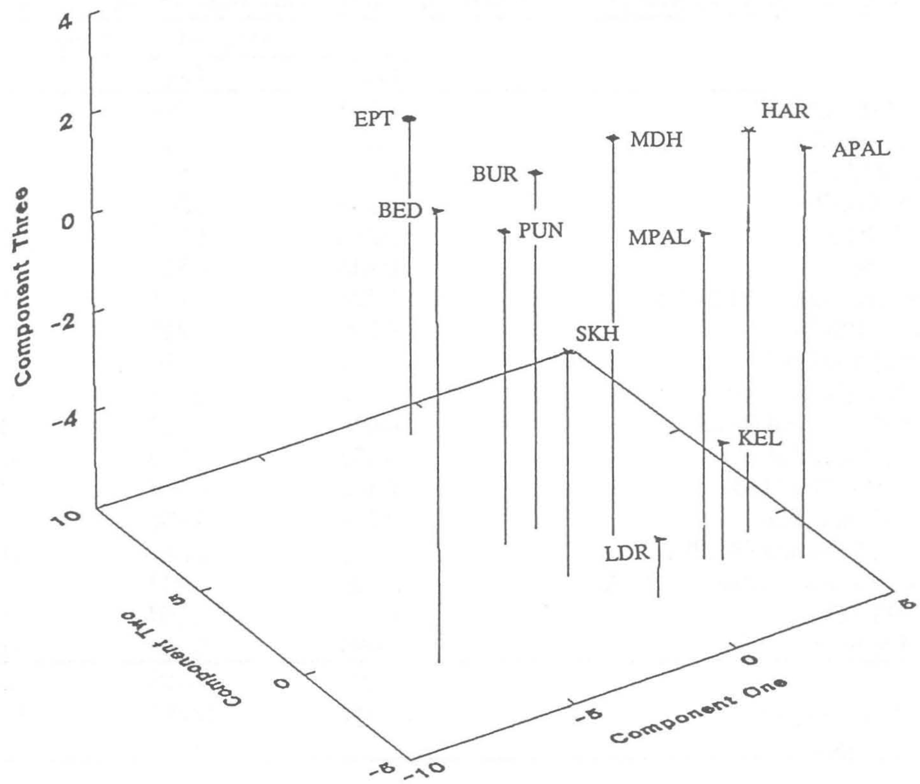

Figure 11.18. Ordination of principal component scores derived from cranial non-metric trait variation among all groups.

Harappa match expectations of the immediate impact of an economy based on intensive exploitation of cultivated foodstuffs. Compared with data from the New World, the degree of deterioration of dental health with increasing reliance on cultivated foodstuffs within the Indus Valley appears not as dramatic (Cohen and Armelagos 1984). Better overall dental health among Harappans may be due to a more diversified diet, which not only continued to include a significant amount of non-domesticated foodstuffs of animal and plant origin, but also included a wide variety of cultigens such as wheat, barley, field peas, sesame, and perhaps rice, millet and sorghum. This dietary diversity enjoyed by Indus Valley cultures may have led to overall better dental health with increased agricultural intensification than was the case with the specialized dependence upon maize, bean, and squash cultivation in North America. However, differences in the bio-geo-chemical features of these two areas of the world may also have exerted an influence on dental pathological affliction.

Examination of caries frequency among prehistoric South Asian dental series provides additional data on the immediate impact of increasing reliance on cultivated foodstuffs on prehistoric South Asians. Figure 11.6 shows a progressive increase in caries rates from lowest levels among mesolithic and neolithic series, moderate levels among chalcolithic cultures, and highest levels among later iron-using (Iron Age) cultures. The uncorrected (6.8%) and corrected caries (12.1%) rates among Harappan phase (R37C) individuals fall within and even exceed the range exhibited by Iron Age sites. The frequency of dental caries among Harappan phase individuals is in accord with the general progressive increase in dental caries from mesolithic to Iron Age cultures and no doubt reflects the combined influence of both increasing reliance upon cultivated foodstuffs and improvements in food processing techniques.

Assessment of tooth size allows an examination of the long term effects of dietary change on the dental elements. Although authorities disagree as to the specific mechanism involved, numerous studies have demonstrated that the transition from hunting and gathering, to incipient agriculturalism, to intensive reliance upon cultivated foodstuffs results in a progressive reduction in the size of the dental elements as well a changes in body size and skeletal tissue development (Kennedy 1984b). Examination of South Asian tooth size by culture type (Figure 11.2)

indicates a general trend from largest tooth size among mesolithic and neolithic cultures to smallest tooth size among Iron Age cultures. This confirms Brace's (Brace and Montagu 1977) prediction for tooth size in the Indian subcontinent that populations with the longest traditions of ceramics, sophisticated cooking techniques, and agriculturalism should possess smallest overall tooth sizes. However, with a total crown area in excess of those found among chalcolithic inhabitants of Inamgaon and Harappa, individuals from the Iron Age culture of Mahurjhari (MHJ) represent a departure from this general trend.

Ordination of total tooth size by age in antiquity (Figure 11.3) permits a more detailed analysis of the relationship between total tooth size, culture type, and age in antiquity. While the regression line derived from these data clearly indicate a trend towards dental reduction over time in South Asia, a key feature of this ordination concerns the position of each sample relative to its predicted value from antiquity. Sites which fall above the regression line possess large teeth relative to their antiquity, while sites located below the regression line possess teeth that are small for their antiquity. Three sites (MDH, INM, MHR) lie above the regression line and four sites (MR3, MR2, TMG, SKH) fall below. Harappan phase cemetery individuals (HAR) are located on the right side of the plot with a total crown area quite close to that predicted from the regression line.

Brace and Montagu (1977) predicted that tooth size within the Indian subcontinent should vary along a cline with smallest tooth sizes in the Indus Valley, medium tooth sizes across peninsular India, and largest tooth sizes in South India and Sri Lanka. Of the three sites that lie above the regression line, one—Mahadaha (MDH)—represents an incipient agricultural economy. With a mixed economic pattern which featured a great deal of hunting and gathering the larger than expected tooth size possessed by mesolithic individuals at Mahadaha probably reflects the South Asian dental condition prior to the reductive effect wrought by agriculturalism. The other two dental series which fall above the regression line include Inamgaon (INM) and Mahurjhari (MHJ). These sites are located in peninsular India where agriculture has a more recent history than in the Indus Valley (Lukacs 1985b, 1991). Mehrgarh (MR2, MR3), Timargarha (TMG), and Sarai Khola (SKH) all fall below the regression line, reflecting small tooth size for their antiquity. This is a pattern consistent with their locations near the Indus floodplain where agricultural subsistence practices have much greater antiquity than in peninsular India (Lukacs 1983). Thus, when tooth size is examined across South Asia relative to cultural type and location, Brace and Montagu's (1977) expected relationships for most intensive dental reduction among those cultures which have experienced sedentary agriculturalism for the longest period of time is borne out.

An equally important finding of this research is difference in dental health between the two sexes, with dental caries and hypoplasia significantly more common among females than among males (Table 11.8). Recent studies among hunter-gatherer and farming groups have demonstrated that gender-based divisions of labor are accompanied by differences in diet (Hill and Hurtado 1989; Walker and Hewlett 1990). Female foragers eat more frequently throughout the day and tend to have greater access to cariogenic foodstuffs such as roots, tubers, and grains, all of which are high in starchy carbohydrates. Conversely, men tend to eat less often than women and habitually consume meat during hunting forays. Meat is less cariogenic than roots, tubers, and grains, and this difference in diet based on sex-based activity patterns results in a less cariogenic diet among males than females (Hayden 1979; Larsen 1983, 1984). The difference in dental caries between the sexes at Harappa may not necessarily be a question of what is eaten, but at what state of preparation that food is consumed (Meadow, personal communication 1991). Meadow reasons that if women prepared the food and snacked fairly regularly at different levels of preparation, while men tended to eat set, fully prepared meals, differences may have accrued between the sexes in both the type and quality of what was eaten. Faunal evidence suggests that Harappans, although agricultural, may have regularly hunted wild game and fished (see Chapters 7 and 8 in this volume). Since hunting and fishing have traditionally been male activities, Harappan men may have consumed a higher protein, less cariogenic diet than Harappan women.

Sex differences in hypoplasia are of interest because it suggests that among Harappan phase children, girls were subject to greater stress during growth than boys. Not only is hypoplasia more common among girls than boys, but examination of the number of lines present on the canine indicates that girls experienced growth disruptions more often than boys. This gender difference in hypoplastic prevalence may be the result of differential access to essential resources, including food, health care, and general parental investment. For example, in Hindu society sons are more highly valued than daughters (Beals 1974; Tyler 1973), and a recent study by Hrdy (1990) demonstrates that this difference in offspring preference leads to higher mortality and more frequent illnesses among daughters than among sons. The disparity in hypoplastic occurrence among Harappan boys and girls has also been found from examinations of dental

microwear (Pastor 1991) and may reflect the biological impact of preferential treatment of sons at the expense of daughters (Lukacs 1991). These observations on adult caries prevalence and on growth disruptions among children contradict the frequently acclaimed egalitarian nature of the Harappan Civilization (Miller 1985; Shaffer 1982, 1984).

Biological Continuity

The rise and fall of the Harappan Civilization has been interpreted by some authorities to be the product of local indigenous development and decay, while others have suggested that these events reflect cultural and possibly biological input from outside the Indus Valley. Key to resolving this debate is determining the biological affinities possessed by Harappan phase populations. If the rise and fall of the Harappan Civilization were solely the products of local South Asian forces, we should expect biological affinities of Harappan phase populations to reflect continuity with Indus Valley populations that both predate and post-date this civilization. If, however, populations from outside the Indus Valley exerted influence over the rise and fall of this Civilization, then we should expect the biological history of the Indus Valley to be marked by biological discontinuities.

One of the major problems in examining biological affinities among South Asians in general, and Harappan phase individuals in particular, is the lack of comparable data sets from a number of relevant prehistoric and living samples. This problem is clearly reflected by the fact that all three lines of biological evidence are available only from the Harappan phase cemetery at Harappa. Nevertheless, the data that are available permit a preliminary analysis of Harappan phase biological affinities.

For clarity, discussion of Harappan phase biological affinities is divided into three related questions. First, what is the relationship between Harappan phase and post-Harappan phase groups at Harappa? Do they share closest biological affinities to one another despite differences in chronology and inhumation practices—the result expected from *in situ* biological continuity? Second, what are the patterns of relationship among South Asians? When considered against samples derived from other parts of the subcontinent, do patterns of affinity indicate biological continuity over time within the Indus Valley? Third, when South Asian samples are contrasted against samples from outside the subcontinent, do patterns of biological affinity indicate that the biological history of South Asia is one of prolonged continuity without significant biological perturbations from adjacent parts of the Near East and Asia?

With the data currently available, relationships between Harappan phase and Late Harappan individuals at Harappa can only be examined from cranial measurements. Contrasted with other prehistoric samples from Pakistan, cluster analysis (Figure 11.7) and principal components analysis (Figure 11.8) indicate that individuals from the Harappan phase cemetery at Harappa possess closest biological affinities with lower (earth) burials from Cemetery H (H2) and with post-Harappan Timargarha. Craniometric data indicate that there is no close relationship between the two Late Harappan Cemetery H samples. This suggests that the dramatic differences in inhumation practices evident in these Late Harappan samples may reflect populations with very different biological affinities. However, this suggestion must be considered tentative, as sample sizes for these Late Harappan burial contexts are small.

Biological relationships among South Asians may be examined from craniometric, dental non-metric, and cranial non-metric data. Craniometric variation among prehistoric populations from Pakistan indicate a strong separation between inhabitants of northern Pakistan (Harappa, Timargarha) and those of southern Pakistan (Mohenjo-daro). This dichotomy is reinforced when these prehistoric samples from Pakistan are compared with modern groups derived from other parts of South Asia. From Figures 11.9 and 11.10, cluster analysis and principal. components analysis consistently identify all prehistoric groups from Pakistan as most similar to one another, with one notable exception—Mohenjo-daro. Mohenjo-daro presents no close affinities to any other South Asian sample, although it must be remembered that not only is the sample from Mohenjo-daro small in number, but its association with the Harappan phase is questionable (Dales 1964; Kennedy 1984a).

Variation in dental non-metric traits among prehistoric South Asians suggests that individuals from the Harappan phase cemetery possess closest biological affinities to individuals from chalcolithic levels at Mehrgarh. Somewhat surprisingly, the neolithic inhabitants of Mehrgarh possess closer affinities to the late chalcolithic inhabitants of Inamgaon than they do the later chalcolithic inhabitants of Mehrgarh. Cluster analysis (Figure 11.13) and principal components analysis (Figure 11.15) indicate that the two post-Harappan northern Pakistani sites of Timargarha and Sarai Khola possess closer affinities to one another than they do to any of the other prehistoric South Asian dental series. These groups possess slightly closer affinities to individuals from the Harappan phase cemetery and chalcolithic Mehrgarh than they do to individuals from the mesolithic Ganga Valley, late chalcolithic Inamgaon, or neolithic Mehrgarh. Multidimensional

scaling of standardized mean measure of divergence distances (Figure 11.14) supports the relationships identified by cluster analysis and principal components analysis with one notable exception. Multidimensional analysis suggests that Timargarha possesses affinities equally close to the Harappan phase cemetery and to Sarai Khola.

Together these dental non-metric results among prehistoric South Asians raise three important points concerning biological continuity within the Indus Valley. First, neolithic and chalcolithic inhabitants of Mehrgarh do not share closest biological affinities to one another, the result expected if these two occupations are reflective of *in situ* continuity. When considered in tandem with the closer relationship of neolithic Mehrgarh to the late chalcolithic inhabitants of Inamgaon, this strong difference between neolithic and chalcolithic inhabitants of Mehrgarh may be indicative of a biological discontinuity within the Indus Valley at some point between 6000 BC and 4500 BC. Second, individuals from the Harappan phase cemetery possess closest affinities to individuals from chalcolithic levels at Mehrgarh, and somewhat distant affinities to post-Harappan individuals from Timargarha. Third, Sarai Khola possesses closest affinities to Timargarha, but no close affinities to any other series. These last two sets of relationships suggest that biological continuity may have existed within the Indus Valley from the early chalcolithic period at Mehrgarh (4500 BC) until the post-Harappan period at Timargarha (800 BC). After this time, however, another discontinuity appears in the biological history of the Indus Valley, for the Early Iron Age inhabitants of Sarai Khola (200 BC) possess a very different set of affinities than those possessed by post-Harappan individuals from Timargarha.

Biological relationships between South Asians and individuals from adjacent parts of the Near East and Asia can be examined from cranial non-metric and craniometric data. Variation in non-metric traits of the cranium confirm that Harappans possess a pattern of biological affinities very different from those found among the inhabitants of Sarai Khola (Figs. 11.16-18). While Sarai Khola possesses somewhat intermediate affinities with mesolithic inhabitants of the Ganga Valley and with modern inhabitants of India (Punjabis) and Burma, Harappans share closest affinities with ancient and modern groups from the Near East. These cranial non-metric results corroborate dental non-metric data that suggest a biological discontinuity exists in the history of the Indus Valley at some point after the end of the Harappan Civilization (1750 BC), but before the Early Iron Age at Sarai Khola (200 BC). In addition, cranial non-metric data suggest that the source of this disruption did not come from the Indian subcontinent but from the West.

Examination of craniometric variation among South Asians and prehistoric samples from the Near East, Anatolia, Egypt, and the Iranian Plateau raises four important points concerning Indus Valley biological continuity and possible biological perturbations from outside the subcontinent. First, there is reasonably good separation between Egyptians, Anatolians, and other South Asians. Second, all Indus Valley sites, except Mohenjo-daro, possess relatively strong affinities to one another. Third, apart from Timargarha and the lower (earth) burials from Cemetery H (H2), Harappan phase cemetery individuals possess closest affinities to individuals from Tepe Hissar 3. Fourth, individuals from Mohenjo-daro possess no close affinities to any other sample included in this analysis.

So what does all this say about Harappa, the Harappan Civilization, and peopling events in South Asia? Renfrew (1987, 1989) has recently put forward two hypotheses to account for the introduction of Indo-European languages into the Indian subcontinent. The first theory, known as the "Neolithic Arya Hypothesis," calls for introduction of Indo-European speakers into South Asia with the development of agriculture. In fact, he specifically states that this would imply that the neolithic inhabitants of Mehrgarh were Indo-European speakers. The second theory is the "Mounted Nomads of the Steppe Hypothesis." This latter theory postulates a movement of Indo-European speakers into South Asia after the end of the Harappan Civilization but before composition of the *Hymns of the Rigveda*. This would imply a movement of Indo-European speaking peoples into the Indus Valley at some point after 1750 BC but before 1000 BC.

The results of this research do not support Renfrew's Neolithic Arya Hypothesis. Rather than demonstrating biological continuity within the Indus Valley from neolithic times to the dawn of the Christian Era, two discontinuities exist. The first occurs between 6000 and 4500 BC and is reflected by the strong separation between the two samples from Mehrgarh. While this discontinuity stands in marked contrast to the archaeological interpretation of Jarrige (1981, 1985; Jarrige and Lechevallier 1979) and others (Lechevallier and Quivron 1981), this discontinuity accords well with archaeological evidence for increasing craft specialization, trade networks, and ceramic similarities to the northwest with Kili Ghul Muhammed and Damb Sadaat (Jarrige 1982). This discontinuity also fits well with recent glottochronological studies which place the entrance of Dravidian languages into South Asia around the 4th millennium BC (Fairservis and Southworth 1989; Gardener 1980;

Southworth 1979), as well as current linguistic research that not only ascribes a common origin to the Dravidian and Elamitic languages (MacAlpin 1974, 1975, 1979, 1981), but suggests that the peoples of the Harappan Civilization were Dravidian language speakers (Fairservis 1983; Mallory 1989; Parpola 1984a,b, 1986).

Together, these data suggest that Harappan phase individuals—and by extension the inhabitants of chalcolithic Mehrgarh and post-Harappan Timargarha —bear closest affinities to populations from the West, i.e., from the Iranian Plateau and the Near East. Similar conclusions have been reached from craniometric analysis by others working with somewhat different data sets (Bartel 1979; Cappieri 1959, 1970; Dutta 1983; Rathbun 1982). Coupled with their differences from the earlier neolithic Mehrgarh sample and from Early Iron Age individuals from Sarai Khola, this pattern of biological relationships complements the ideas of Lamberg-Karlovsky and Kohl who proposed an "early interactive sphere" of trade and communication between the Indus Valley and the Iranian Plateau beginning in the 4th millennium BC. With closest biological affinities outside the Indus Valley to the inhabitants of Tepe Hissar 3 (3000-2000 BC), these biological data can be interpreted to suggest that peoples to the west interacted with those in the Indus Valley during this and the preceding proto-Elamitic period and thus may have influenced the development of the Harappan Civilization.

The second biological discontinuity exists between the inhabitants of Harappa, chalcolithic Mehrgarh, and post-Harappan Timargarha on one hand and the Early Iron Age inhabitants of Sarai Khola on the other. This implies another discontinuity at some point after 800 BC but before 200 BC. The loose association of the post-Indus site of Sarai Khola with the two Anatolian sites, along with their separation from the Harappan and pre-Harappan groups indicate a change during the millennium following the end of the Harappan Civilization. This latter difference could be interpreted as support for Renfrew's "Mounted Nomads of the Steppe" hypothesis, but clearly much more work needs to be done in this area.

The biological data discussed here presents no strong disagreement with the archaeological evidence presented by Mughal (1990). The Harappan Civilization does indeed represent an indigenous development within the Indus Valley, but this does not indicate isolation extending back to neolithic times. Rather, this development represents internal continuity for only 2000 years, combined with interactions with the West and specifically with the Iranian Plateau.

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Cover art: Bowl on Stand H88-1002/192-17 associated with Burial 194a
in Harappan Phase Cemetery (see Figure 13.18).

12

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Cover art: Bowl on Stand H88-1002/192-17 associated with Burial 194a in Harappan Phase Cemetery (see Figure 13.18).

13

Summaries of Five Seasons of Research at Harappa (District Sahiwal, Punjab, Pakistan), 1986-1990

George F. Dales *(Project Director)*,
Jonathan Mark Kenoyer *(Assistant Director)*,
and the staff of the Harappa Project

A summary of five seasons of archaeological investigations at Harappa is presented in the form of excerpts taken from preliminary reports provided after each season to the Department of Archaeology and Museums, Government of Pakistan. Presented in this way, these reports give the reader some idea of how the work at Harappa progressed from year to year, with each season's work building on the results of the previous.

This chapter is a summary of the objectives and accomplishments of each season's work at Harappa (Figure 13.1). Excerpts have been taken from the preliminary reports submitted after the close of each season to the Department of Archaeology and Museums, Government of Pakistan. These will convey to the reader the character of the project as it developed over the five years from 1986 to 1990. Interpretive statements presented in the reports of individual seasons are of a preliminary nature and relevant to the particular season. More synthetic discussions can be found in the papers in this volume, while final evaluation must await completion of data analysis and stratigraphic correlations. Personnel for each season are generally not noted in the following text except in the case of specialists. Instead they are listed in Chapter 12 of this volume. Likewise, funding sources are acknowledged in Chapter 1.

First Season: January—Mid-April, 1986

Project Objectives

Our knowledge of the urban aspects of the Indus Civilization is conditioned primarily by the discoveries made in the 1920s and 1930s at Mohenjo-daro and, to a lesser extent, at Harappa. Both sites were excavated extensively and lengthy reports were published. The emphasis in those early days was on architecture and artifacts—the physical remains of the civilization that could be seen, touched, and displayed in museums. Without those initial discoveries and publications, this earliest urban civilization of South Asia would not be known to us today. But the objectives and standards of present-day archaeological research demand a different set of data recovered

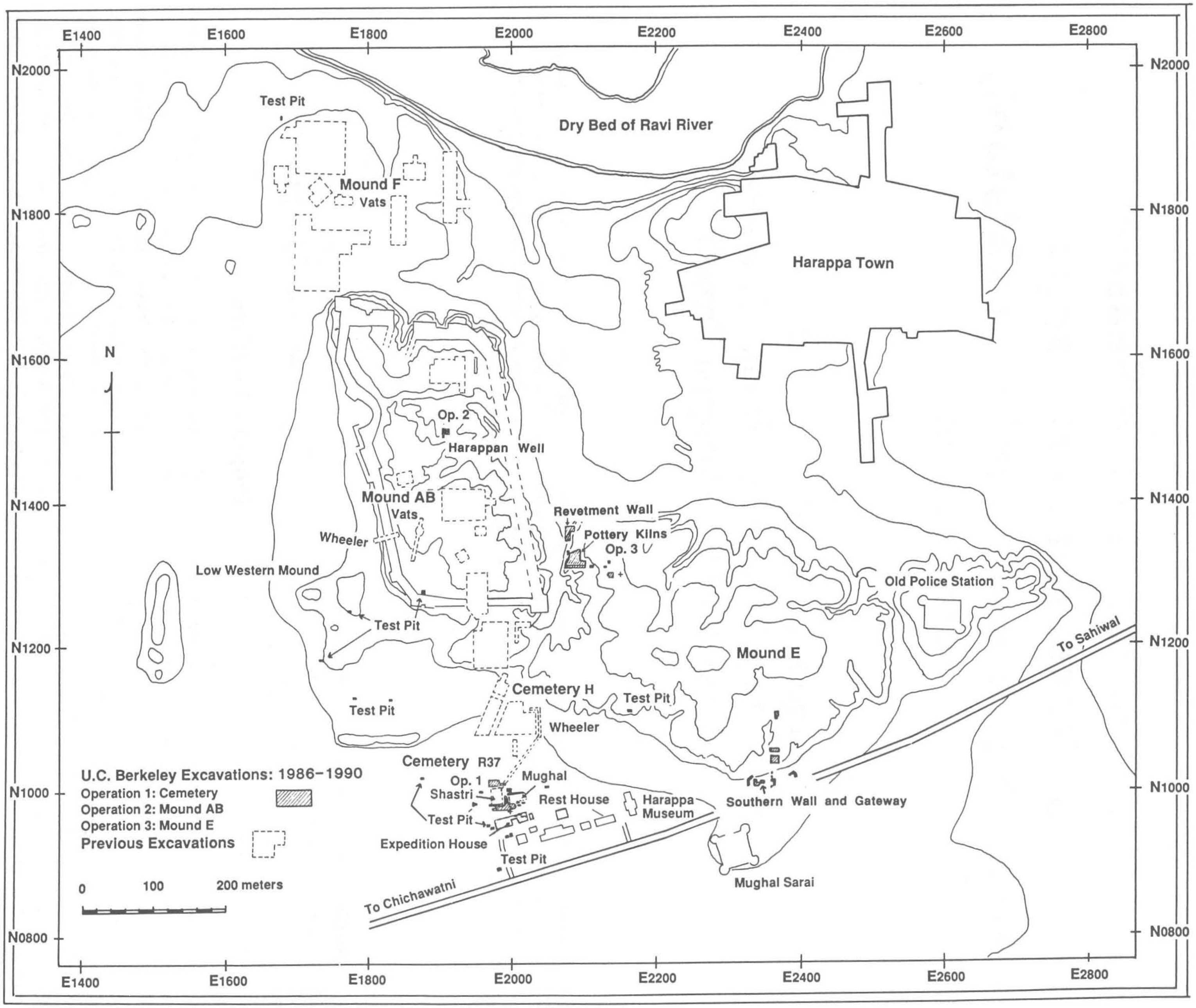


Figure 13.1: Harappa 1990 site plan showing extent of excavations.

through the use of modern techniques in order that quantitative and interpretative analyses can be made. The collection and analyses of floral, faunal, palaeoecological, settlement pattern, and other data are essential. The return to earlier excavated sites such as Harappa is important not only because they are so rich in basic data but because the stereotyped conceptions of the sites and of the civilization they represent are in need of drastic reevaluation based on modern research strategies and techniques.

Objectives for the First Season

A. *Excavation and Survey*
  1. Mapping and grid system
  2. Survey
  3. Exploratory trenches

B. *Conservation and Site/Museum Development*
  1. Establishment of conservation procedures.
  2. Construction of expedition house and field laboratory.

C. *Training program for Pakistani graduate students*

Description of Work Accomplished

A. *Excavation and Survey*

1. Mapping and grid system

In spite of our best efforts, none of the original bench marks used for the site plan published by M.S. Vats (1940) could be located. It was necessary, therefore, to utilize the Survey of Pakistan benchmark located at the bridge on the Lower Bari Doab canal (between Harappa and Harappa Station) and to traverse back to the site in order to install new permanent concrete benchmarks. These benchmarks were established in a new site grid that was laid out with metric measurements and oriented to sidereal rather than magnetic north (Figure 13.2).

2. Surface survey

Surface surveys of the entire site and the surrounding plain identified numerous surface features, pottery, and other artifacts that might indicate areas of specialized activities. Of primary concern were those areas of the site that were only briefly described by earlier excavators. These include the low western mounds and the adjacent flood plain, the southeastern mound that is covered with heavy growth (Mound E), and the northeastern mound that is covered by the present-day Harappa city. In addition to these unexcavated areas, eroded sections of previous excavations were examined as were all the dumps from previous excavations to give us an idea of the types of artifacts that might have been overlooked by earlier excavators. These preliminary surveys were conducted in units which correspond to major erosional patterns of the site. At plain level where no erosional features were evident, the survey unit was a 50 square meter grid. When concentrations of artifacts were detected, their coordinates within the grid unit were recorded and their locations plotted on the new site plan.

On Mound AB, all recognizable dumps from previous excavations were examined along with selected portions of the uppermost excavated surfaces. Because of the complicated erosion of the citadel edges—partly natural and partly exaggerated by the massive robbing of bricks in the 19th century—more detailed surveys must await the installation of grid markers for smaller units at one to five meter intervals.

A general survey of the cultivated and inhabited areas to the west and south of the site was made to determine the extent of debris scatter. The fields and habitations north of the site and beyond the dried bed of the river Ravi were examined to see if there were any remnants of ancient habitation in that direction. Many hamlets and two larger village mounds were examined, but only modern debris was noted. The same situation holds true for the modern town of Harappa where recent construction and debris build-up appears to have largely obliterated any original Harappan or Late Harappan occupational deposits. Modern drains, for example, dug to a depth of one meter reveal only modern debris. But the town is built on an obvious mound and further investigations are required. [*Harappan remains were noted in the excavation of a foundation for a house on the northwest side of Harappa city in 1989.*] Areas to the east of the town have yet to be surveyed.

Several important features of the site have been revealed by the surface surveys. The low mound to the west of Mound AB (called the "Low Western Mound"– Figure 13.1) is made up of Harappan phase debris—mostly pottery—with no evidence of structures at the surface level. Localized concentrations of chert debris, agate flakes, sandstone/quartzite flakes, and vitrified pottery and nodules suggest that the mound may have been an industrial part of the city. Two small test pits (numbers 11 and 12) on the mounds revealed only Harappan phase dump deposits with no indications of working floors or structures (see below for details).

On the plain just to the south of this low mound, two small test pits (numbers 9 and 10) revealed the presence of a Harappan brick structure occurring in between major debris layers. Several other long low mounds that are covered with Harappan phase sherds and artifacts are located even farther west of Mound

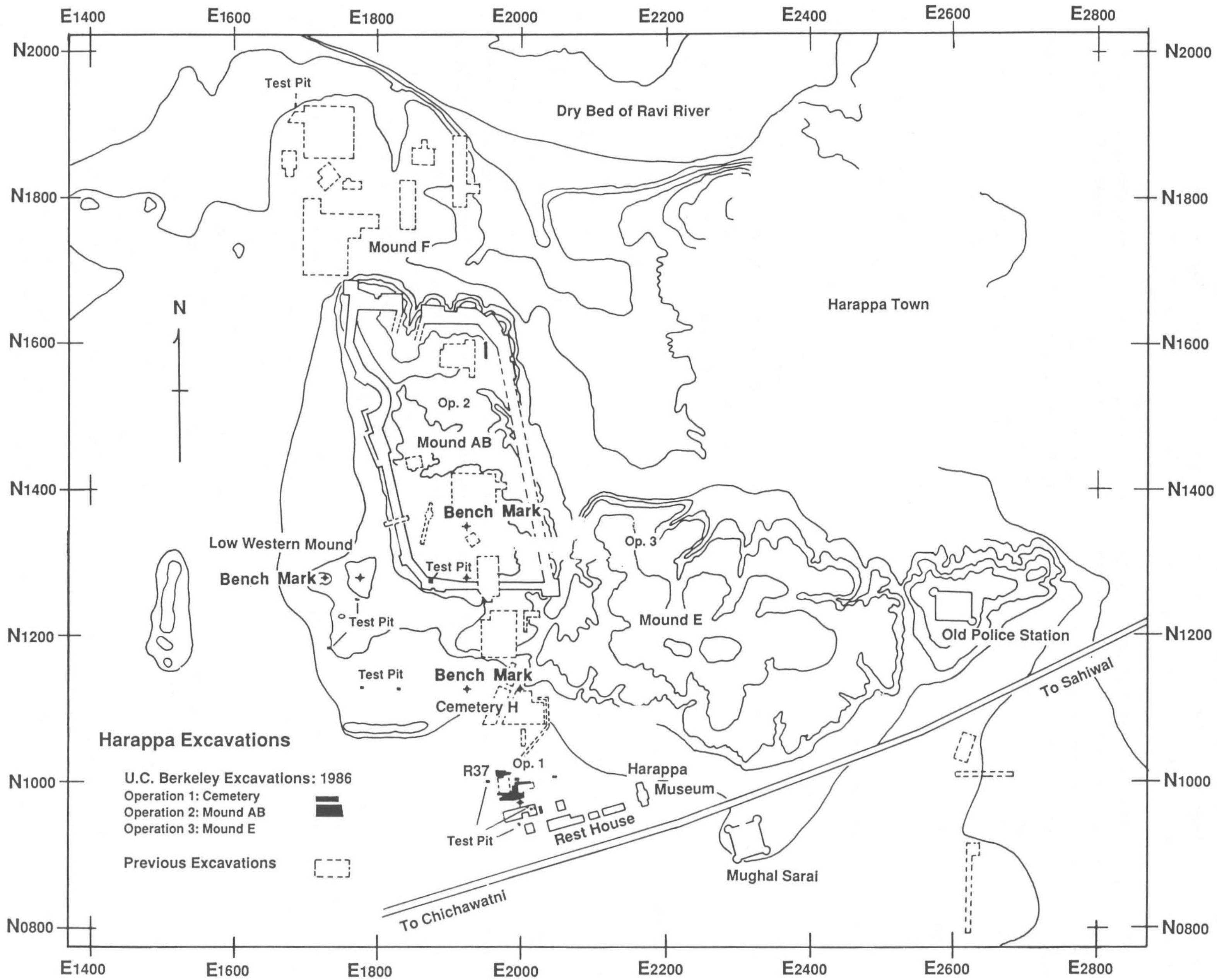


Figure 13.2: Harappa 1986 site plan showing location of test pits and benchmarks.

AB. Their east-west or north-south orientations at the edges of modern fields suggest that they may be the result of repeated scrapings or gradings of the adjacent fields to remove potsherds, nodules, and saline soil. Future excavations will be required to test this hypothesis.

The surface survey of Mound E turned up many interesting features. Along the southern slope of the mound are indications of *in situ* Harappan structures marked by brick walls, mud-brick platforms, sump pits, and habitation deposits. Evidence for production of agate beads, stone tools, ceramics, shell ornaments, and perhaps copper implements was located at the extreme eastern end of Mound E (Old Police Station mound). Important features identified at the northwestern corner of Mound E include an ancient kiln, *in situ* fired brick drains, and habitational debris. Fragments of Late Harappan (Cemetery H) pottery were found on the top of the mound in this area. Although the northern slope of Mound E has been affected by modern activities, occupational debris was noted in sections in the gullies, and numerous Harappan artifacts such as stone tools, beads, and terra-cotta objects were collected. The top of Mound E is covered by trees and vegetation and thick aeolian sediments. Square and rectangular shaped surface features are found scattered across the entire length of the mound, and they are oriented in many different directions. Some of these structures resemble mud-brick walls, but there is no distinctive pottery to determine if they are ancient or modern. They will be examined in more detail next season.

Along the entire western edge of the Mound AB are enormous dumps left by the 1946 excavations of Mortimer Wheeler (Wheeler 1947). "Early Harappan" sherds similar to those discovered by Wheeler beneath his so-called "defense wall" were recovered all along the tops of these dumps. This is an important discovery because it provides additional evidence that there was a substantial Early phase settlement at the site. An additional area of interest on Mound AB lies at the southeastern corner of Vats's principal excavations. Here there were found numerous pieces of sawn steatite and also vitreous slag from what might be faience production. The deposits visible in the section cut by the present walkway do not appear to be in primary context, and they may well be the result of workshop debris having been dumped as fill between or inside other structures during the ancient occupation of the area.

3. Exploratory Trenches

During this first season, 14 exploratory trenches were excavated (Figure 13.2). Nine of these trenches (numbers 1-8 and 13) focused on determining the extent of the Harappan phase cemetery (R37) in preparation for large-scale excavations planned for the second season. The evidence from these explorations indicates that little if any of the cemetery is preserved south of where the original R37 excavations were conducted.

Test Pit 1 (G.F. Dales, supervisor): A 1 × 2 m pit was excavated to a depth of 2.5 m (160.0 m AMSL). Five strata were recorded consisting of alluvial soil covered by Harappan pottery debris characteristic of the thick debris layer reported by Wheeler (1947) and Mughal (1968) to cover Cemetery R37. No structures or burials were encountered.

Test Pit 2 (Thomas Gensheimer, supervisor): A 1 × 2 m pit was excavated to a depth of 1.5 m (161.35 m AMSL). Five strata were recorded. In stratum 4, a disturbed and fragmentary Harappan burial was encountered consisting of a few complete pottery vessels, a few fragmentary human bones, and a fragment of a human skull.

Test Pit 3 (John Berg, supervisor): A 1 × 2 m pit was excavated to a depth of 2.0 m (161.13 m AMSL). The five strata were similar to those in pits 1 and 2. In the lowest level, hard packed clay may represent the remains of a disturbed burial lining, but no actual burial was found.

Test Pit 4 (G.F. Dales, supervisor): In a 1 × 2 m pit were encountered, 0.7 m below the surface, a Harappan pottery ring stand and a medium-sized globular pot that probably was originally placed in the stand. About a meter to the southwest, at a similar depth, was found a group of 17 Harappan pottery vessels. These 19 pieces may all have come from the same grave, but no bones or other burial evidence were found.

Test Pit 5 (G.F. Dales, supervisor): After clearing brush and other surface debris, a 1 × 2 m pit was dug along the southern edge of the depression left from Shastri's Cemetery R37 excavations in the early 1940s. The soil was all dark brown down to a depth of about 2 m (161.1 m AMSL) where a surface of calcium carbonate accretions was encountered. This being probably an original natural surface, excavation was stopped. Only one pottery item—a complete Harappan vertical handled cup—was found in this pit.

In clearing the surface just to the east of Pit 5, between it and the western edge of Mughal's 1966 cemetery excavations, well preserved mud-brick walls were found. They were probably the linings of Cemetery R37 burials excavated by Shastri.

Test Pit 6 (G.F. Dales, supervisor): To investigate the possible extension of Cemetery R37 to the west of Shastri's excavations, a test pit was dug at the bottom of the western side of Shastri's dump. This 2 × 2 m pit was located between the dump and the cultivated field

to the west. The upper levels consisted only of debris from the dump and silty deposits from a modern irrigation ditch at the base of the dump. Lower deposits appeared to be secondary in nature and contained very little pottery, a few fragmentary bones, and one animal figurine. No traces of intact cemetery materials were found. Excavations stopped at a depth of about 1.5 m below the surface (c. 161.68 AMSL).

Test Pit 7 (Thomas Gensheimer and G.F. Dales, supervisors): At a depth of about 1 m, this 1 × 2 m test pit turned up a few very fragmentary bones and a large group of Harappan pottery. More than 40 pottery vessels were found in what was probably an intact burial, but the closeness to the surface in this heavily watered garden area resulted in the deterioration of the burial itself and seriously altered the surfaces of much of the pottery. Excavation stopped at a depth of about 1.4 m when clean, presumably natural, sediment was encountered.

Test Pit 8 (G.F. Dales, supervisor): To test for the possible extension of the Harappan cemetery to the east of earlier excavated areas, a 1 × 2 m test pit was dug just to the east of the cement walk at the eastern edge of the known cemetery. The excavations was taken to a depth of 2.8 m (160.53 m AMSL), where natural sediment was reached. Most of the deposit in the pit consisted of a thick and dense deposit of Harappan pottery—broken and incomplete vessels and sherds, some fragmentary bones, charcoal, and occasional artifacts. The largest percentage of the pottery consisted of "pointed base" or "Indus" goblets. This debris deposit is identical to those described by Wheeler (1947) and Mughal (1968) in their reports on Cemetery R37 excavations.

Test Pit 13 (J.M. Kenoyer, supervisor): This 2 × 2.5 m pit was excavated to a depth of about 2 m (160.0 m AMSL) and yielded relatively clean layers of alluvial deposit with a few Harappan potsherds. No evidence of cemetery material was found.

Four trenches were excavated in the plain to the west of Mound AB: two in the plain itself and two into the low mounds mentioned above. Thick deposits of Harappan debris, fragmentary remains of Harappan walls, possible hearths, and dump areas were recorded.

Test Pit 9 (Thomas Gensheimer, supervisor): The plain to the southwest of Mound AB is covered with Harappan sherds and with what appear to be the remains of industrial activities. Test Pits 9 and 10 were dug to investigate the nature of two of the areas that looked most promising from the surface survey. Pit 9, 1 × 2 m in area, was dug to a depth of 2.5 m (161.5 m AMSL). Fourteen strata consisted mostly of different types of Harappan debris. Stratum 6 contained remains of what may have been a hearth or manufacturing workshop. Stratum 7 also had ash and may represent an earlier workshop or hearth. The lowest stratum was of clean sand and may represent the original ground surface.

Test Pit 10 (Thomas Gensheimer, supervisor): Located about 50 m west of Test Pit 9, this 1 × 2 m pit was excavated to a depth of 2.1 m (161.96 m AMSL). Eleven strata with Harappan materials were recorded. Strata 2-5 consisted of debris associated with the corner of a baked brick wall. The function of this structure was not determined. The lowest stratum appeared to be natural sediment.

Test Pit 11 (J.M. Kenoyer, supervisor): This pit and Test Pit 12 were excavated on the Low Western Mound (see above). This 1 × 2 m pit was dug to a depth of 2.8 m (161.8 m AMSL). Eight strata were recorded, the upper seven consisting of Harappan debris with no structural remains. The lowest stratum was of clean sediment and may represent the original land surface.

Test Pit 12 (J.M. Kenoyer, supervisor): This 1 × 2 m pit was excavated to a depth of about 3 m (164 m AMSL) on the highest point of the Low Western Mound. No structures were encountered. Three recorded strata consisted of massive deposits of Harappan debris comprising mostly sherds.

Test Pit 14 (G.F. Dales, supervisor): The largest test pit, starting with an area of 3 × 4 m that ended up as 1.5 × 1.7 m at a depth of 6.7 m (161.54 m AMSL), was sunk in the bottom of a deep erosion gully within the southwestern corner of Mound AB. The purpose of this excavation, located to the south of Wheeler's "great trench," was to examine the area for the presence of the Early Harappan settlement suggested by the discovery by Wheeler of Early Harappan pottery along the western edge of the mound. Making use of the erosion gully considerably reduced the amount of overburden that had to be removed. Also, the pit is located farther inside Mound AB than was reached by Wheeler's trench. We hoped that this location would offer a better opportunity for exposing an Early Harappan occupation level than farther toward the perimeter where only sherds had been found.

With the exception of a single stratum of intact Harappan occupational remains in the uppermost level, the remaining strata consisted of fill, debris, and wash, much of it sloping down from east to west. These debris layers were extremely rich in animal bones and botanical remains. Two distinctive Early Harappan sherds were found in the lowest stratum just above natural soil. This lowest stratum was sloping from east to west and appeared to be water-deposited wash. Thus, even though the trench was dug about 1.5 m deeper than Wheeler had gone, no

evidence for a substantial Early Harappan settlement was found. The steep slope of much of the debris suggests that it was deposited over the edge of a higher area, perhaps the massive wall published by Wheeler (1947) or an earlier stage of the same wall not yet defined.

Conclusions: The 9 test pits in and near the Harappan cemetery (R37) confirmed the presence of disturbed and water-destroyed burials in the area south of Mughal and Shastri's excavations. Pottery groups were encountered, but only fragmentary human skeletal remains were found in some of the test trenches. The constant water logging from gardening activities has had a destructive effect on much of the pottery, with surfaces deteriorated almost to a red powder. The two pits to the east of the earlier cemetery excavations confirmed the findings by Wheeler (1947) and Mughal (1968) of an enormously thick stratum of Harappan debris covering the cemetery.

The four test pits in the plain to the west of Mound AB revealed thick deposits of Harappan debris and manufacturing waste. With the exception of the brick wall in Test Pit 10, no traces of architecture were found.

The largest test pit (No. 14), sunk within the southwestern corner of Mound AB, provided further evidence that there is an Early Harappan occupation beneath the Harappan phase remains. A major effort will be made in future seasons to find and expose the actual occupation levels.

A total of 176 artifacts, comprising pottery, beads, figurines, inscribed objects, bangles, etc., was recorded, catalogued, and turned over to the Custodian of the Harappa Museum. Some 176 lots of excavated sherds were also recorded. Diagnostic and unusual examples were drawn, described in detail, and photographed. The best preserved of the remaining sherds were bagged for future study.

B. *Conservation and Site/Museum Development*
1. Establishment of conservation and preservation procedures

A temporary conservation laboratory was set up in one of the rooms of the old museum building by Donna Strahan of the Smithsonian's Conservation Analytic Laboratory. During this first season Ms. Strahan advised and assisted in acquiring the basic equipment and supplies and in designing a laboratory to be included in the newly built expedition house. One important task was to establish procedures for desalinating excavated artifacts. An electric water distillation unit was purchased and tests were made on a variety of artifact types to determine the best procedures for their cleaning and preservation.

2. Construction of Expedition House and Field Laboratory

A major achievement of this season was the construction of an expedition complex on museum property just south of Cemetery R37 (Figure 13.3). This complex includes sleeping quarters for up to 15 persons, an eating area, and laboratory facilities. The 23 × 30 foot laboratory is equipped with independent systems for running water and electricity and has adequate space for the treatment of the anticipated volume of excavated materials (Figure 13.4).

C. *Training Program for Pakistani Graduate Students*

Although full-scale excavations were not undertaken, a program of field training for a small group of Pakistani graduate students was begun. Dr. Javed Husain of Karachi University brought four of his students to Harappa for a three week field session. They assisted in surveying and mapping; helped in classifying, describing and drawing pottery and objects; received basic instruction in conservation techniques; and participated in methodological and theoretical discussions relating to the interpretation of archaeological data.

Second Season: January-April, 1987

Objectives for the Second Season

A. *Excavations and Analyses of Scientific Samples*
   1. Harappan Cemetery (R37)
   2. Mound AB
   3. Mound E

B. *Palaeoenvironmental Studies*
   1. Palaeozoological and Palaeobotanical Studies
   2. Pedological and Palaeoclimatic Studies

C. *Conservation and Site/Museum Development*

D. *Training Program*
   1. Pakistani Graduate Students
   2. Conservators

Description of Work Accomplished

A. *Excavations and Analyses of Scientific Samples*
1. Harappan Cemetery (R37)

The main focus during the second season was the further delimitation and excavation of the Harappan cemetery that had been excavated in part by Shastri in 1939 (unpublished), Wheeler in 1946 (1947), and Mughal in 1966 (1968) (Figure 13.5). Eleven additional test pits were excavated (Figure 13.6) and of these,

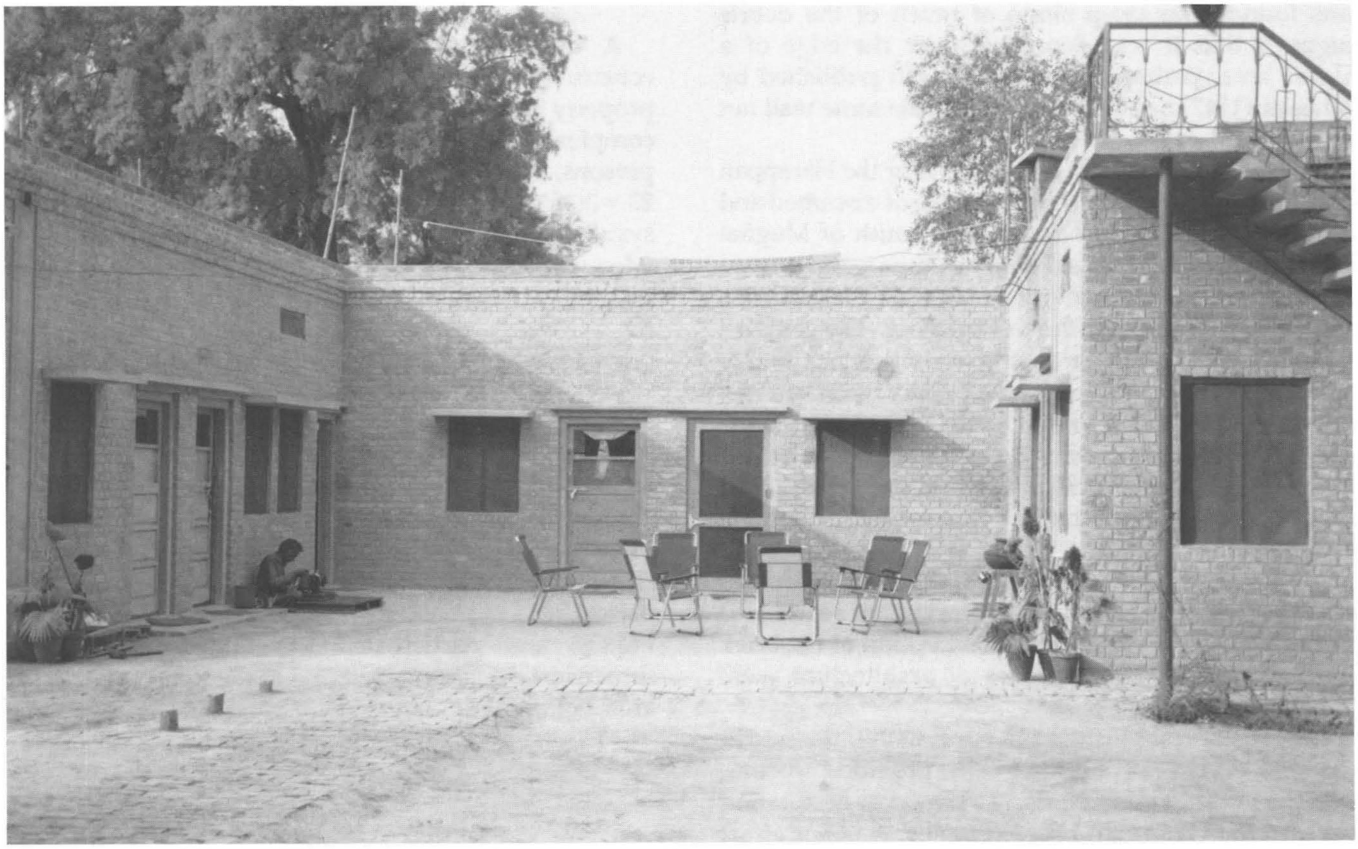


Figure 13.3: Harappa expedition house, constructed in 1986.

Figure 13.4: Conservation and research laboratory in Harappa expedition house.

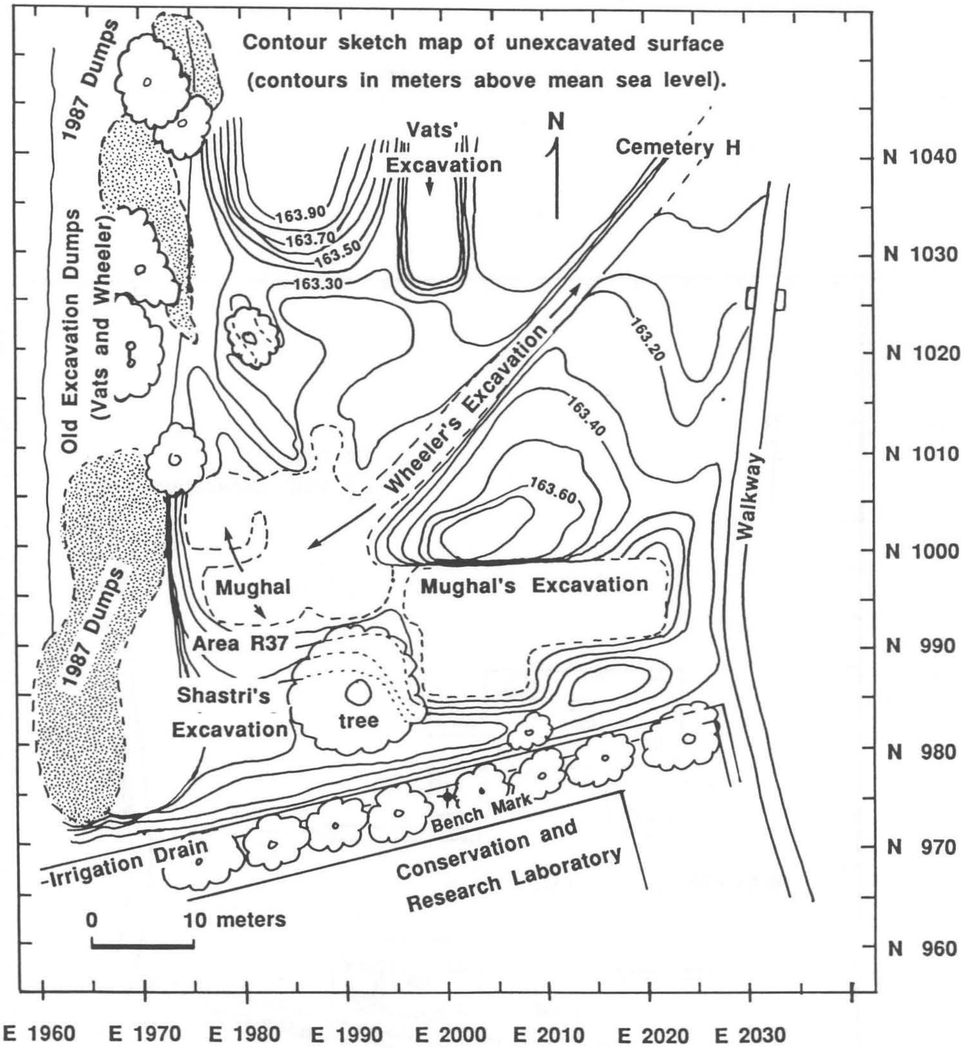


Figure 13.5: Harappa 1987 cemetery excavations: contour sketch map of unexcavated surface and temporary dump areas.

eight turned up primary context or eroded burials. These burials were then more fully exposed, and by the end of the season, 371 square meters within the cemetery area had been opened up, with some locations excavated to natural sediment and others to varying depths depending on the presence or absence of burials.

Although the cemetery excavations were carried out under the supervision of J. Mark Kenoyer and various graduate students, a team of four physical anthropologists was closely involved in the delicate excavation of the actual skeletons and their subsequent removal to the laboratory for further analysis. Each anthropologist had a different speciality: K.A.R. Kennedy, morphometrics; John R. Lukacs, dental anthropology; Nancy Lovell, palaeopathology and palaeodietary reconstruction; and Brian Hemphill, discrete traits analysis. The detailed report of the skeletal remains will be presented by the physical anthropologists when they have completed their analyses; however, tentative identifications of the primary context burials indicate that 8 were female and 3 were male.

In terms of excavation procedures, all of the sediment from the test pits and burial areas was screened and all artifacts, including tiny potsherds and bead fragments, were collected for further analyses. The vast amount of sediment from the thick debris layers was carefully examined by hand. All cultural materials, including pottery, minute fragments of beads, figurines, chipped stone, and fragments of human and animal bone were collected for tabulation and further analysis. The procedure for systematically recording and coding stratigraphic layers, archaeological features, and artifacts will be presented in the final report.

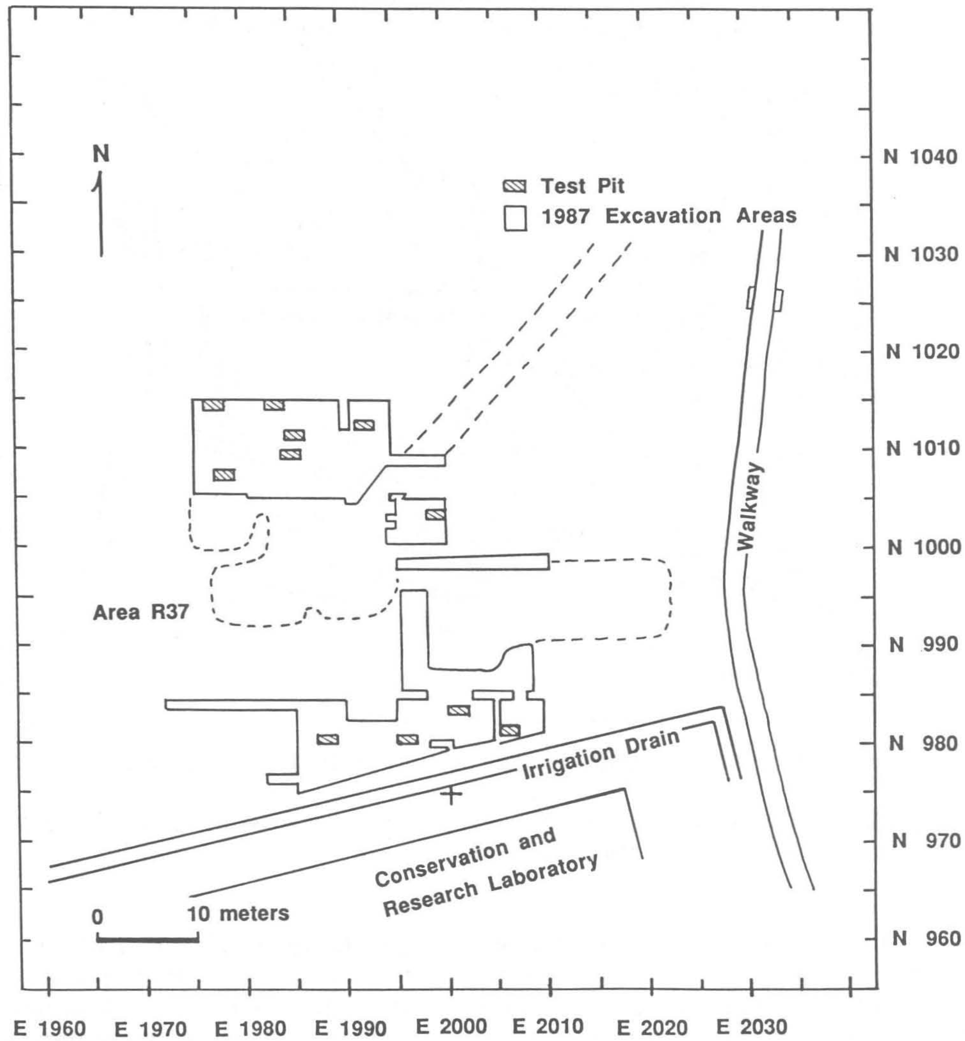


Figure 13.6: Harappa 1987 cemetery excavations: location of test pits and total excavated area.

Although the results of these excavations are not conclusive, they suggest that the main concentration of *in situ* burials is along an east-west axis just north of the modern irrigation ditch (Figures 13.7 and 13.8). To the south of the ditch are disturbed and eroded burials, to the east are eroded sediments with a thick overburden of debris, while in the west are similar eroded sediments and a thick debris deposit. The northern limit of the primary context burials needs to be better defined, after which it will be possible to estimate the size and total extent of the cemetery area. At this point it appears that this cemetery represents only a small segment of the population of the ancient city, and there may be more extensive cemetery areas in other parts of the site.

The primary context burials were all located in the area where the original land surface is still preserved at the level of the modern surface. All of the primary context burials are in distinct rectangular pits, but there are also collections of human bone that appear to have been removed from burials and dumped on the slope or in shallow depressions.

Most of the burials had been disturbed by the intensive use of this area by the Harappans themselves (Figure 13.9). They dug into previous burials to make room for later burials, disturbing or entirely removing the earlier skeletons and burial pottery (Figure 13.10). From the preliminary observations of the burials, it appears that there are several modes of burial represented with a wide variety of burial goods. All but one of the Harappan burials are extended and supine, with the head to the north and the feet to the south.

Three of the burials had traces of coffins which were indicated by dark staining in the sediment (Figure 13.11), but no microstructural traces could be identified. One coffin burial had what appears to have been a lid, and it was possible to collect samples of this for later identification.

The range of burial goods includes quantities of pottery vessels arranged at the head and foot of the grave shaft. In some burials the pottery was placed in the grave first and then partially covered with sediment. The body was then placed level with the top of the pottery, after which the grave was completely filled. The subsequent weight of the sediment often crushed the coffin and underlying pottery, resulting in a disturbed burial. Other burials had the pottery arranged at the same level as the body. Some of the later burials that cut into and disturbed the earlier burials were supplied with only a few vessels or no burial pottery at all.

Almost 40 percent of the 553 artifacts registered this season are complete or restorable pottery vessels recovered from the burials and the overlying debris. The preservation of the surfaces of the vessels varies considerably. Many vessels have reddish slips and/or black painted decoration in good condition whereas other vessels, sometimes from the same burials, have only fragile traces of surface color. The explanation for this seemingly differential preservation of vessel surfaces is under study. In one of the earliest burials, a large painted vessel had its design intentionally obscured by an outer coating or coatings of a clay-like material; this may have been applied by the Harappans to protect the elaborately decorated surface. [*See Figure 5.2 in Chapter 5 of this volume. Additional vessels with similar surface treatments were found in this burial in the following season.*] This is the first recorded example of such a practice at Harappa. At Mohenjo-daro, however, there is a sherd of a vessel that was first decorated with black, red, green, and yellow designs and subsequently covered with a thick white plaster-like coating (Dales and Kenoyer 1986: figure 88:8b and plate 17E). Such secondary surface treatment is a practice that may have been relatively common but has gone unrecognized until now.

Preliminary analysis of the ceramics suggests that the painted pottery is generally limited to the lowest and hence earliest burials, while in the later burials most of the pottery is unslipped and unpainted. There are, however, some exceptions to these patterns. [*See Dales, Chapter 5 of this volume.*]

Significant new aspects of Harappan ornamentation are seen in these burials, including shell bangles, a copper ring, steatite disc beads, carnelian and lapis lazuli beads, black stone amulets, and a unique ornament made of three shell rings, a jasper bead, and hundreds of steatite microbeads.

Four burials of what are probably adult females were found with shell bangles on their left arms (Figure 13.12). The bangles were arranged on both the lower and upper arm, with the characteristic Harappan chevron motif pointing counter clockwise. One burial had 14 shell bangles, another had seven, another had five, while the final had only two. Once we have relative dates on these burials, these bangles may provide an important clue to stylistic variation over time.

A distinctive form of black stone amulet has been discovered in three of the burials, all of which are probably females. One amulet was actually found *in situ* at the 3rd to 4th cervical vertebrae, suggesting that it was worn at the throat or possibly placed in the mouth at the time of burial. Two of the burials had carnelian beads—one on the right hand near the pelvis and one on the left pelvis, and one burial had a carnelian and a lapis bead under the edge of the left pelvis. In one burial a copper/bronze ring was found on the middle finger of the left hand. An anklet of approximately 300 steatite disc beads was found in

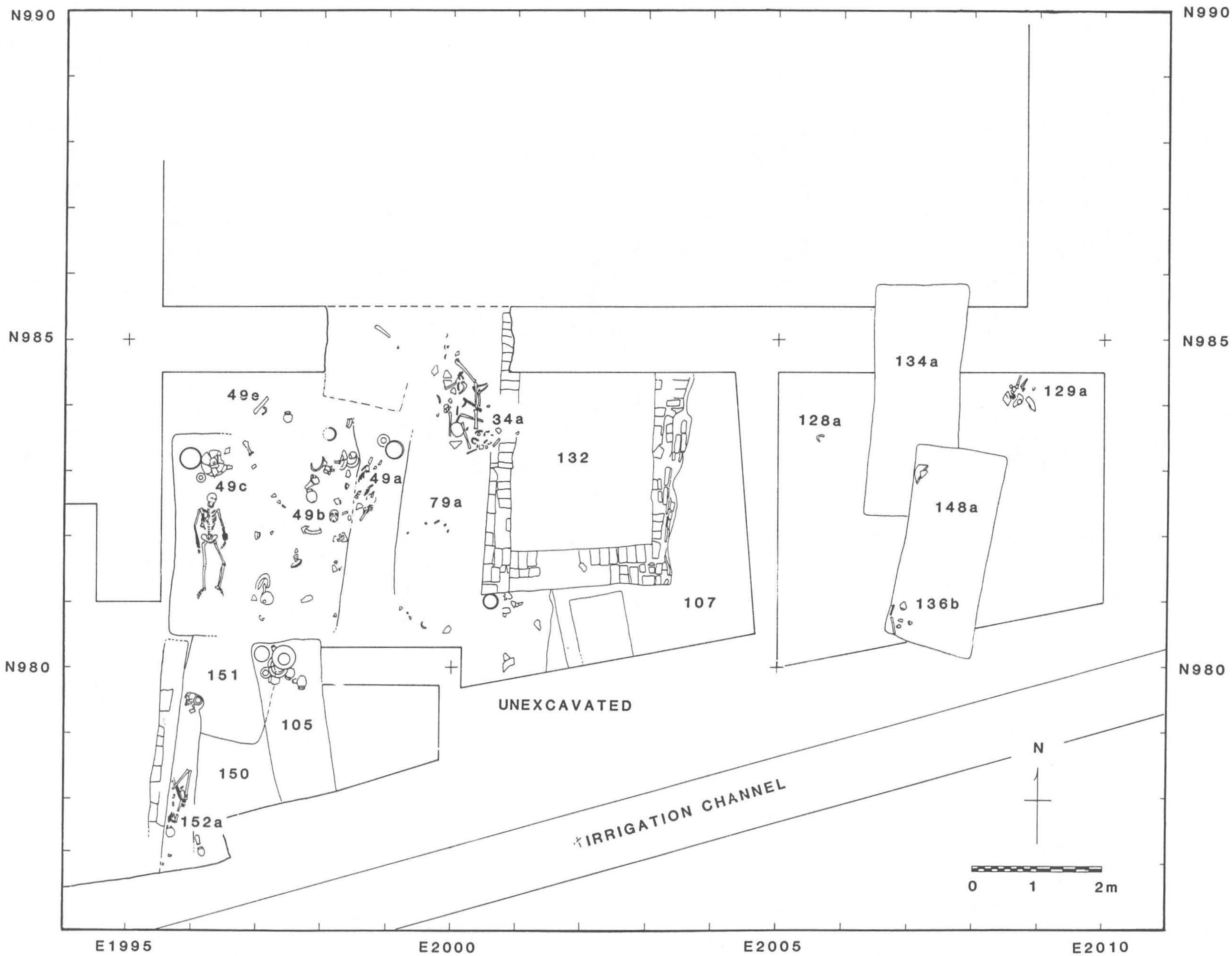


Figure 13.7: Harappa 1987 cemetery excavations: plan of upper levels with feature numbers.

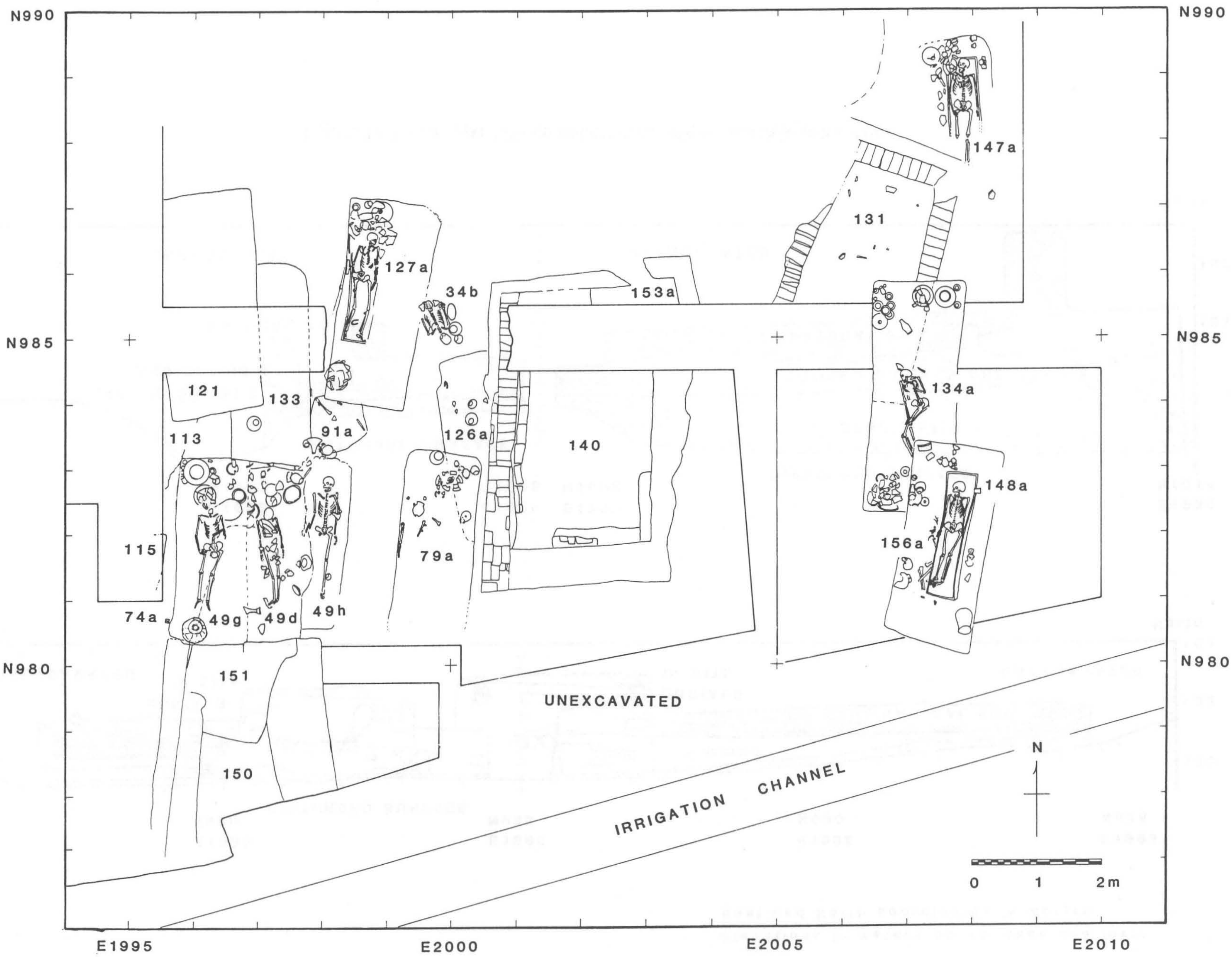


Figure 13.8: Harappa 1987 cemetery excavations: plan of lower levels with feature numbers.

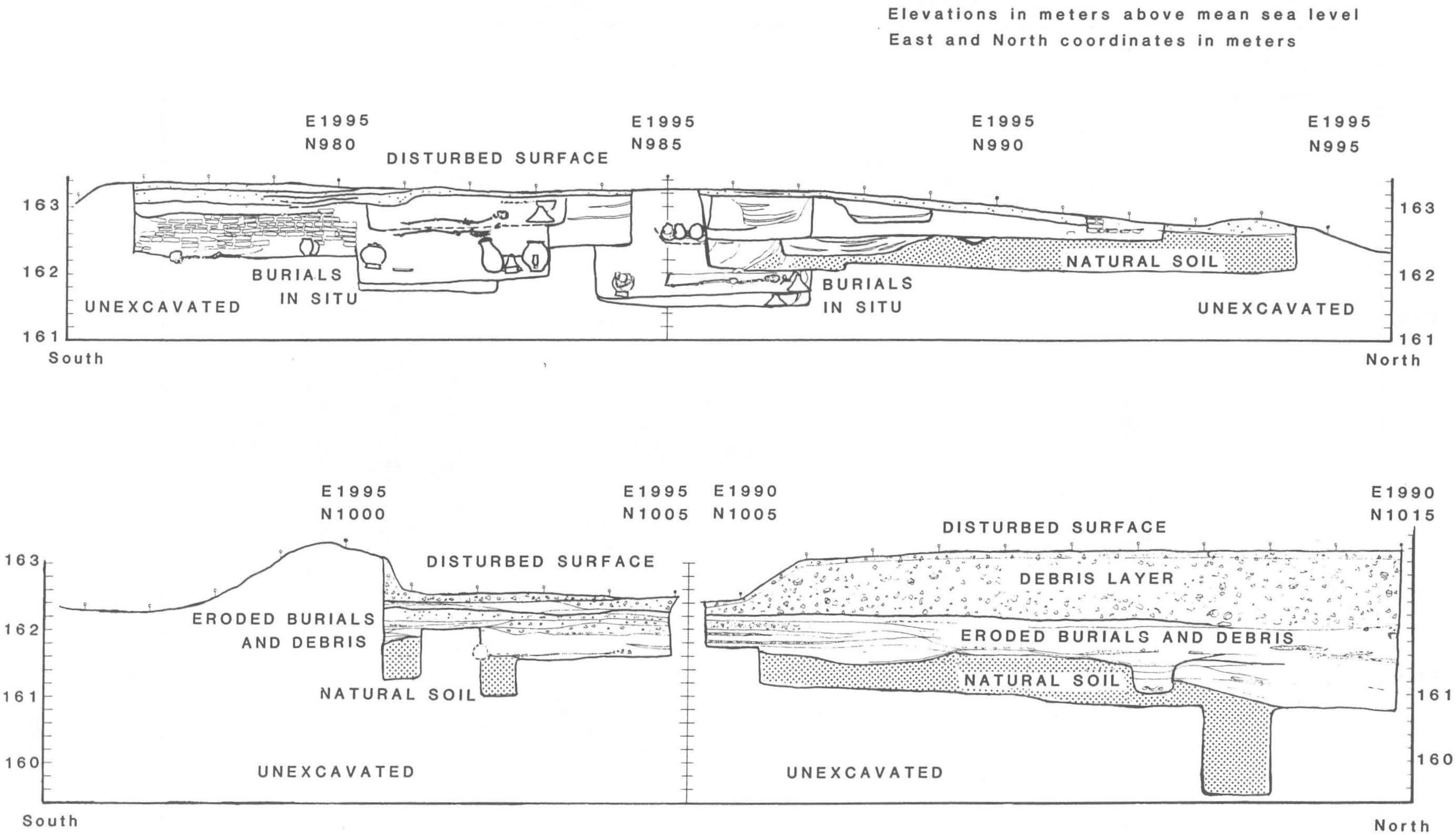


Figure 13.9: Harappa 1987 cemetery excavations: north-south sections.

Figure 13.10: Harappa 1987 cemetery excavations: Burials 134a and 148a (see Figure 13.8).

one burial, while the most dramatic ornament consisted of three shell rings, a jasper bead and a collection of hundreds of tiny microbeads that were located to the right of the skull. This was found on what was probably an adult male (Lot 136, Feature #[147a]—Figure 13.11) who was buried in a coffin with over a dozen vessels arranged at the head of the pit and additional vessels along the side of the pit. On the left wrist was a shell bangle and near the right hand a carnelian bead.

2. Mound AB

The expedition began excavations in one of the large erosion gullies at the northeastern corner of Mound AB (the citadel mound) ("Op.2" in Figure 13.1). The objective was to obtain a sequence of occupational and structural remains going down to natural soil with the hope also that intact remains of the Early Harappan settlement would be located. A 10 meter square area straddling the central part of the gully was marked out for the excavation. Relatively well preserved remains of fired brick floors and drains as well as mud-brick walls with fired brick foundations were found just below the erosional debris of the gully. These structures on both sides of the gully appear to be related to broad floorings—or platforms?—of mud-brick that covered the entire center of the gully. Excavations will be continued in this area next season.

A considerable quantity of Late Harappan, Cemetery H, pottery was found in the uppermost levels on both sides of the Mound AB gully. Mud-brick structures seen in section have different sized bricks than the standard Harappan structures, and it is likely that they may be architectural remains related to the otherwise unknown Cemetery H period (Late Harappan phase) occupation of the site.

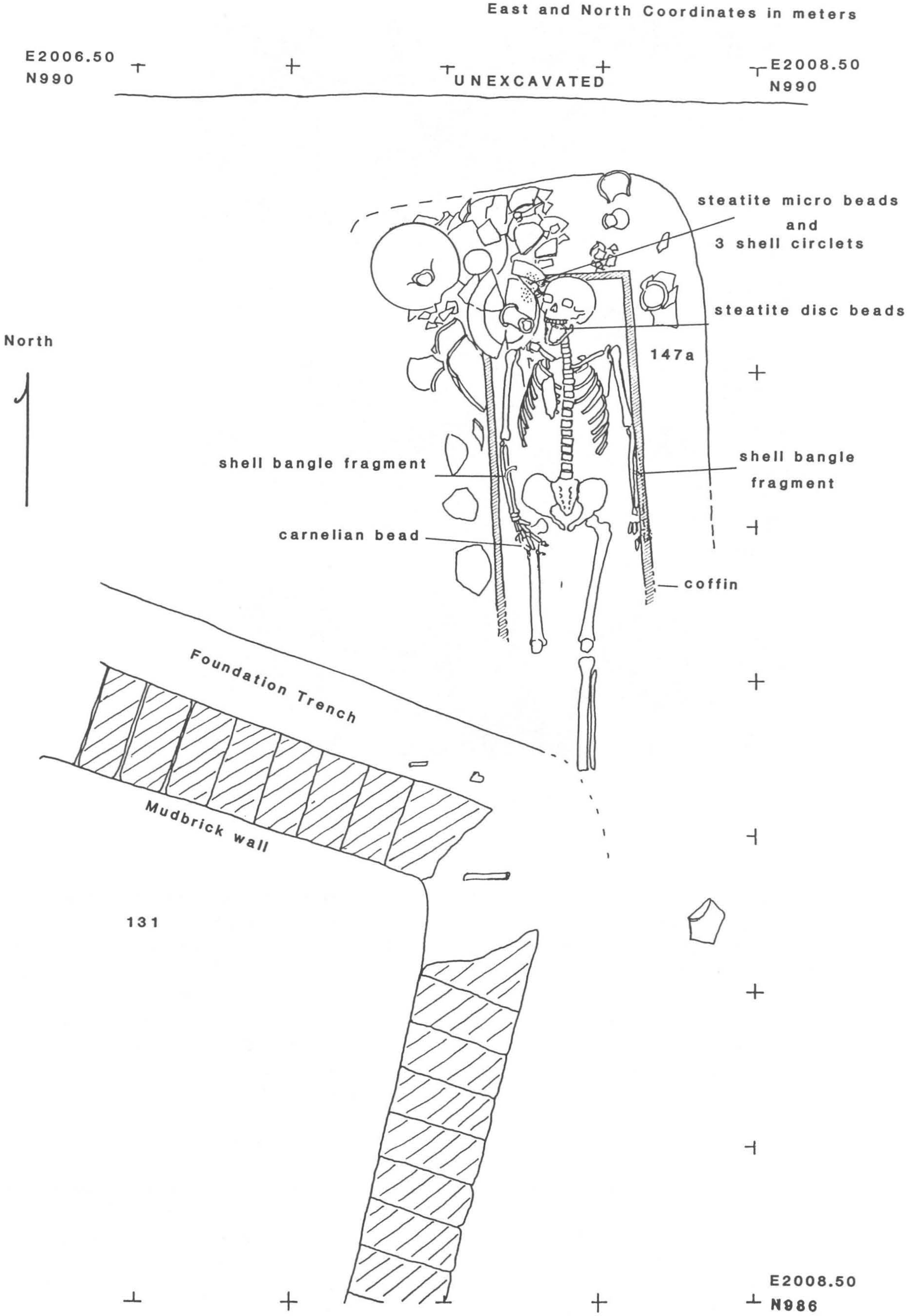


Figure 13.11: Harappa 1987 cemetery excavations: Burial 147a (see also Figure 13.8).

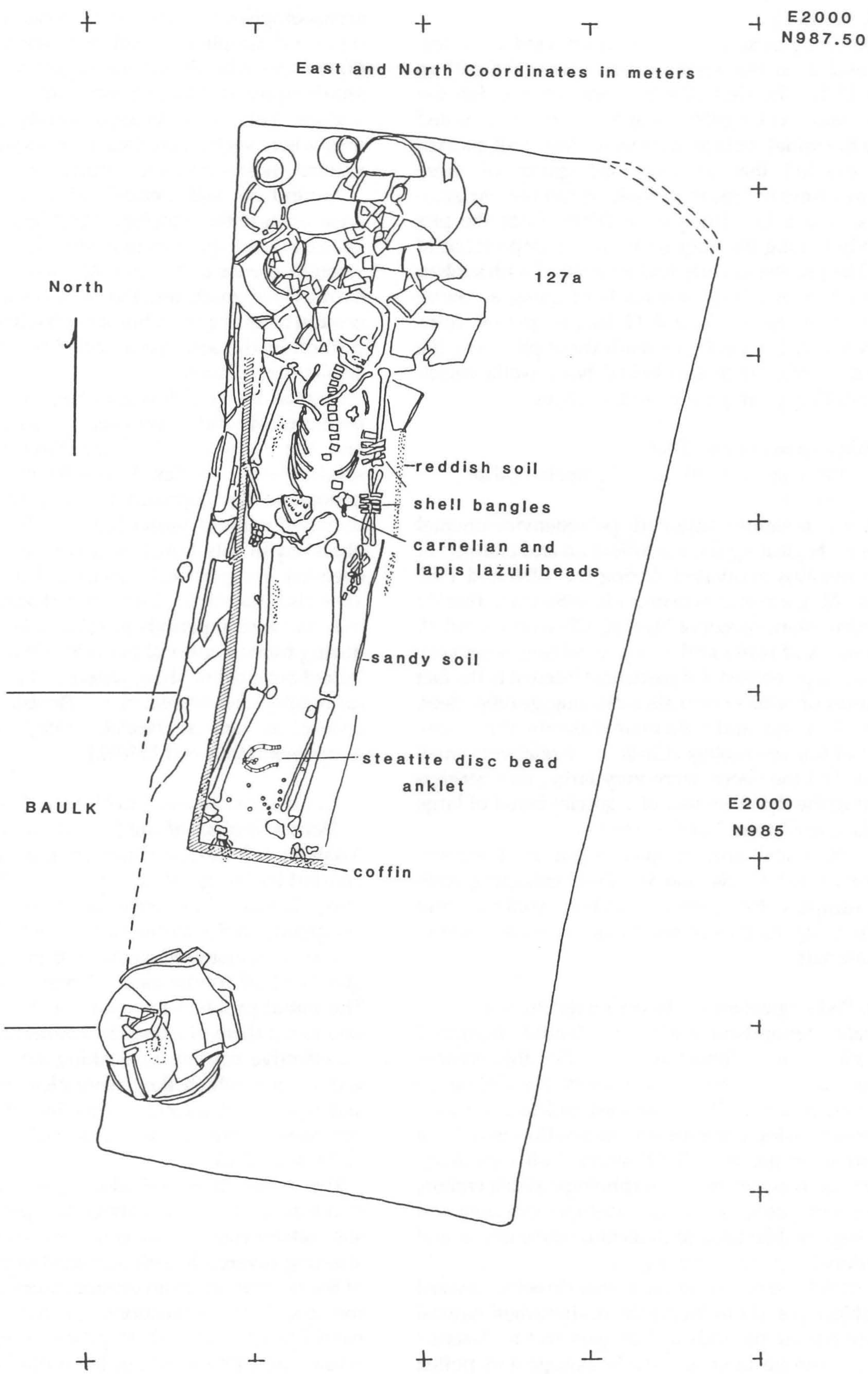


Figure 13.12: Harappa 1987 cemetery excavations: Burial 127a (see also Figure 13.8).

3. Mound E

Preliminary excavations were conducted at the top of Mound E on the northwestern corner ("Op.3" in Figure 13.1). The first objective was to examine the square and rectangular shaped structures noted during the initial surface surveys in 1986. Test excavations revealed that at least one group of these structures were the result of shallow rectangular excavations, where the dirt and brickbats from the pits were piled along the edges, giving the impression of walls. The pits themselves had been filled with aeolian sediments from which fragments of glass, a cowrie shell (*Cypraea monetas*), and 12 Islamic period coins were recovered. Directly beneath these pits were the remains of mud-brick and baked brick walls associated with Harappan pottery and artifacts.

B. *Palaeoenvironmental Studies*

1. Palaeozoological and Palaeobotanical Studies

Richard Meadow initiated palaeoenvironmental studies by beginning the identification and analysis of animal remains excavated during the 1986 and 1987 seasons. All the bones excavated in 1986 from Test Pit 14 (southwestern corner of Mound AB) were recorded. The remains of cattle and sheep dominate, with very few goats represented. Of particular interest is the fact that bones of wild mammals including gazelle, deer, blackbuck, nilgai, and wild boar make up almost one quarter of this assemblage. Cattle were relatively small animals, but the sheep were very large, this perhaps indicating the development of a special breed of large animals. [*See Chapter 7 in this volume.*]

Palaeobotanical studies will begin next season. Preliminary work this year involved collecting sediment samples for possible pollen analysis and recording impressions of grains and grasses found in clay materials.

2. Pedological and Palaeoclimatic Studies

Ronald Amundson and Elise Pendall launched pedological and palaeoclimatic studies this season. The long range objective of such work is to define the environment of the site in the past and to determine the extent to which climate and vegetation may have changed over the past 5,000 years. Soil chemistry; particle size analysis; micromorphology; stable carbon, oxygen, and possibly nitrogen isotope analyses; and palynology will be used to determine the climatic and vegetational history of the region.

The initial work this season was directed toward three objectives: (1) to locate the undisturbed natural soil beneath the mounds at Harappa and to describe and then sample them for stable isotope and pollen analyses; (2) to examine sections exposed by the archaeologists to look for evidence of soil development and sample such soils for chemical analysis; and (3) to work with the archaeologists in interpreting the stratigraphy and in reconstructing the original land surface. This work focused mainly in the cemetery area where vertical sections were exposed in the excavations, mostly down to natural soil.

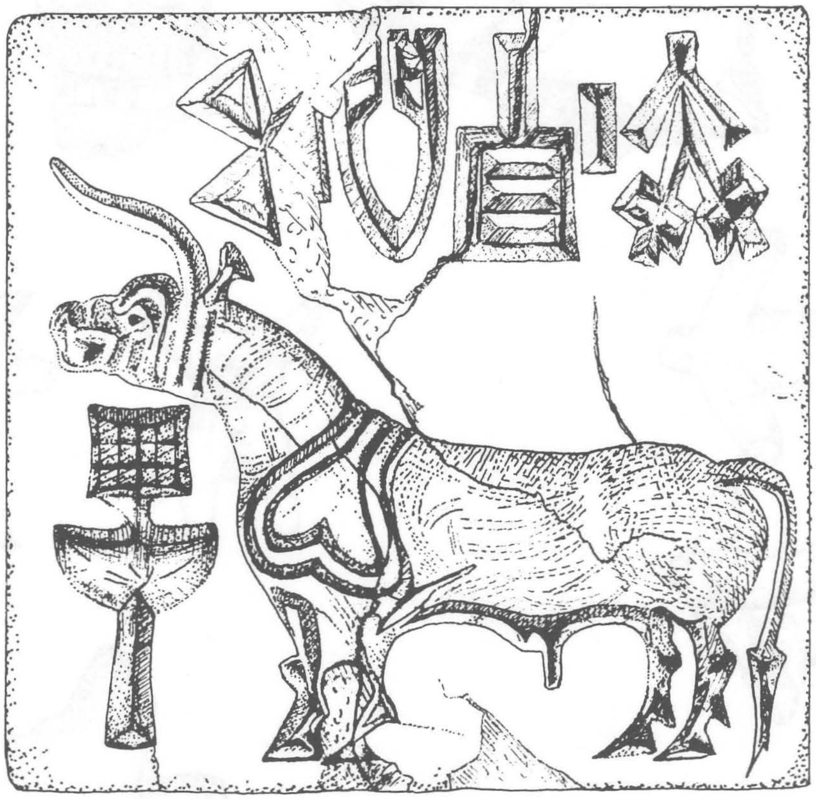
Amundson and Pendall also investigated other areas outside the cemetery. Most importantly, Test Pit 14, excavated the previous season within the southwestern corner of Mound AB, was cleaned out, and corings were made into the natural soil. It appears that erosion resulting from human activity removed a large portion of the soil profile prior to being covered by artifact-rich debris.

A small test trench was excavated at the northwest corner of Mound F, between the so-called "granary" and the former bed of the Ravi to facilitate the soil/sediment studies. Two soils, or strata exhibiting pedogenic development (organic matter accumulations and minimal *kankar* ($CaCO_3$) development), were observed in this trench and samples were taken for chemical and physical analyses. If, as expected, these are soils rather than other types of sediments, it would indicate several periods of relative landscape stability during human cultural periods. Although this section lacked charcoal or shell, *kankar* (caliche) was collected for dating. [*See Amundson and Pendall, Chapter 3 in this volume, as well as Pendall (1989) and Pendall and Amundson (1990a and 1990b).*]

C. *Conservation and Site/Museum Development*

Donna Strahan of the Smithsonian's Conservation Analytic Laboratory returned this season and was assisted by Margaret Leveque of the Museum of Fine Arts, Boston. The importance of having a well equipped, competently staffed field laboratory was clearly demonstrated as the staff treated considerable quantities of fragile skeletal materials and artifacts. The initial problem for many of the excavated items was to rid them of salts. The conservators established an effective routine of soaking artifacts in distilled water, after which they were cleaned, consolidated, and repaired. A selection of the inscribed material and figurines so treated is illustrated as Figures 13.13, 13.14, and 13.15.

The conservation staff also worked with the excavation team and the site curator on specific problems of site conservation. In the cemetery excavations, plastic sheeting covered by soil was used to protect the edges of the excavations from erosion. Some low areas left by the previous excavations in the cemetery were partially filled in both to protect them from further erosion and to also retain the outlines of the excavations for visitors to see.



HT 2.6
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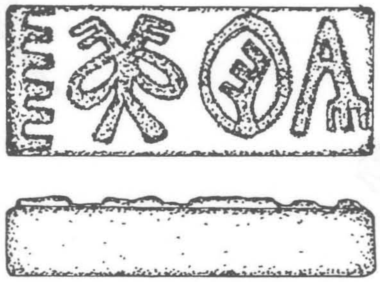

Scale 2:1

2

Figure 13.13: Harappa 1987: (1) steatite stamp seal (H87-262/14-01 – height 26 mm, breadth 26.5 mm); (2) faience token (H87-214/37-02 – height 10 mm, breadth 24 mm).

The project also initiated measures to consolidate and protect some of the eroding areas associated with the earlier excavations on Mound AB. These areas include the southern edge of the mound where over-enthusiastic visitors climb the walls and destroy the edges of the excavations and around the top of the huge trench dug by Wheeler in 1946. Cement posts, metal railings, and barbed wire fencing were erected

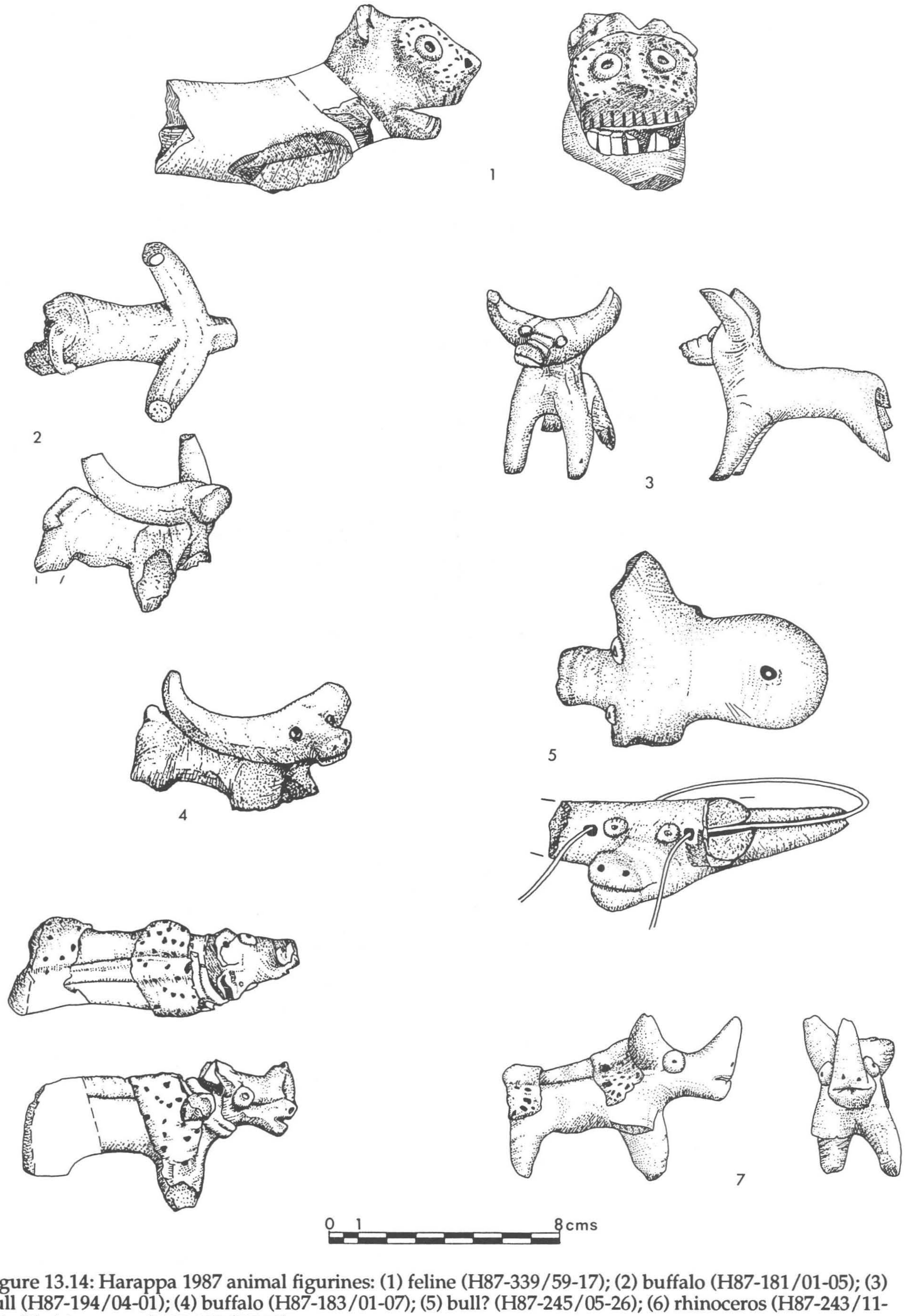

Figure 13.14: Harappa 1987 animal figurines: (1) feline (H87-339/59-17); (2) buffalo (H87-181/01-05); (3) bull (H87-194/04-01); (4) buffalo (H87-183/01-07); (5) bull? (H87-245/05-26); (6) rhinoceros (H87-243/11-49); (7) rhinoceros (H87-283/57-18).

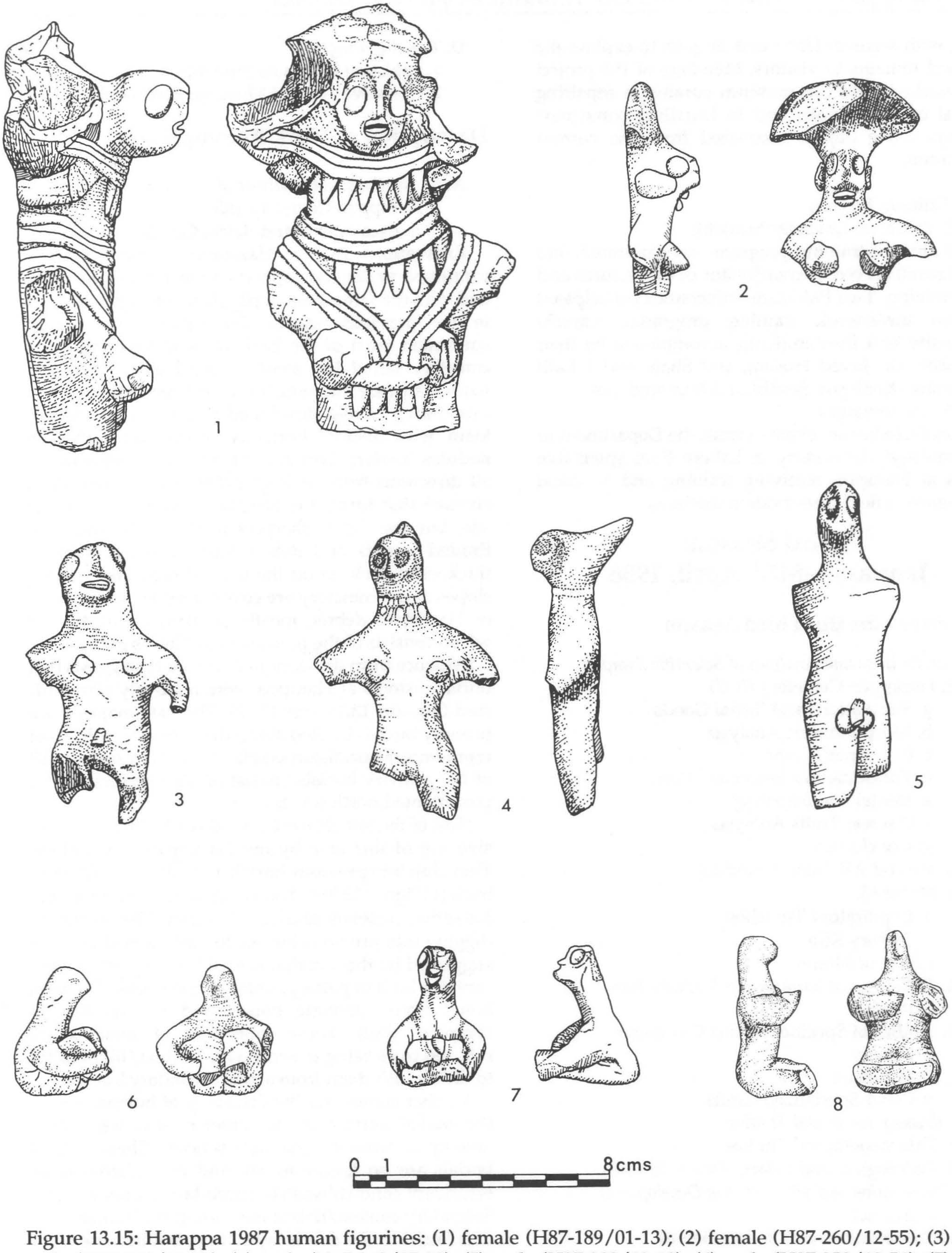

Figure 13.15: Harappa 1987 human figurines: (1) female (H87-189/01-13); (2) female (H87-260/12-55); (3) male (H87-185/01-09); (4) male (H87-248/05-29); (5) male (H87-209/12-48); (6) male (H87-259/12-54); (7) male (H87-196/04-03); (8) male (H87-428/62-20).

along with signs in Urdu and English to explain the exposed remains to visitors. Members of the project also worked with the museum curator in repairing several of the exhibits and in installing some new displays using objects recovered from the current excavations.

D. *Training Program*
1. Pakistani Graduate Students

The student training program was continued, and Julie Lowell served as coordinator of the lectures and field training. Two Pakistani universities participated in two three-week training programs. Karachi University sent four students, accompanied by their professor, Dr. Javed Husain, and Shah Abdul Latif University (Khairpur, Sindh) sent four students.

2. Conservators

Toseef-ul-Hassan, chemist from the Department of Archaeology's laboratory in Lahore Fort, spent five weeks at Harappa receiving training and practical experience in field conservation methods.

Third Season: January—Mid-April, 1988

Objectives for the Third Season

A. *Excavations and Analyses of Scientific Samples*
- 1. Harappan Cemetery (R37)
  - a. Excavations and Burial Goods
  - b. Morphometric Analysis
  - c. Palaeopathology
  - d. Palaeodietary Reconstruction
  - e. Dental Anthropology
  - f. Discrete Traits Analysis
  - g. Conclusion
- 2. Mound AB, Deep Sounding
- 3. Mound E
  - a. Exploratory Trenches
  - b. Pottery Kiln
  - c. Top of Mound
- 4. Collection of Samples for Radiocarbon Dating
- 5. Studies of Specific Artifact Categories
  - a. Pottery
  - b. Figurines
  - c. Other Specialized Crafts

B. *Palaeoenvironmental Studies*
- 1. Palaeozoological Studies
- 2. Pedological and Palaeoclimatic Studies

C. *Conservation and Site/Museum Development*
- 1. Personnel
- 2. Conservation and Restoration of Excavated Materials
- 3. Assistance to Site Curator

D. *Training Program*
- 1. Pakistani Graduate Students
- 2. Conservators and Museum Personnel

Description of Work Accomplished

A. *Excavations and Analyses of Scientific Samples*
1. Harappan Cemetery (R37)
a. Excavations and Burial Goods

Excavations in the Harappan phase cemetery continued under the supervision of J. Mark Kenoyer and with the same team of physical anthropologists as in the previous season. Excavations this season confirmed most of the basic observations about the cemetery noted last season. (See Figure 13.9.) The natural surface into which the cemetery was dug is a raised area of well-developed fine sandy to silt-clay loam with distinct horizons of calcium carbonate nodules (*kankar*). This ancient surface slopes away in all directions from its high point near the irrigation channel that forms the official southern limit of the site, but the dip is sharpest to the north and east. Eroded burials and debris form layers of varying thickness which lie on the natural soil. The eroding slopes of the cemetery are covered by a massive layer of Harappan debris, mostly pottery, about 40% of which consists of the pointed-base "Indus goblets."

Evidence from the Harappan cemetery suggests that burial customs at Harappa were relatively standardized (Figures 13.16 and 13.17). The vast majority are primary burials located along the east-west ridge that represents the undisturbed Harappan land surface. All of the primary burials consist of distinct rectangular pits oriented north-south.

Most of the burials have been disturbed by the intensive use of this area by the Harappans themselves. They dug into previous burials to make room for later burials (Figure 13.18), disturbing or entirely removing the earlier skeletons and burial pottery. The practice of digging into previous burials to make a new grave is suggested by the fact that the fill in every grave shaft contains broken pottery, isolated fragments of human bone, often complete bones, and in one case, a complete skull. These collections of remains are referred to as being in secondary context/fill in order to distinguish them from actual secondary burials.

Another context for the discovery of human bone is the eroded surface of the cemetery that was subsequently covered by the debris layer. These eroded burials are no longer *in situ* and are referred to as secondary context/wash or secondary context/debris. Secondary context/debris means that the human bone was found in the debris layer itself, but because all of the human bone in the debris layer occurs at the interface between the debris layer and the eroding cemetery

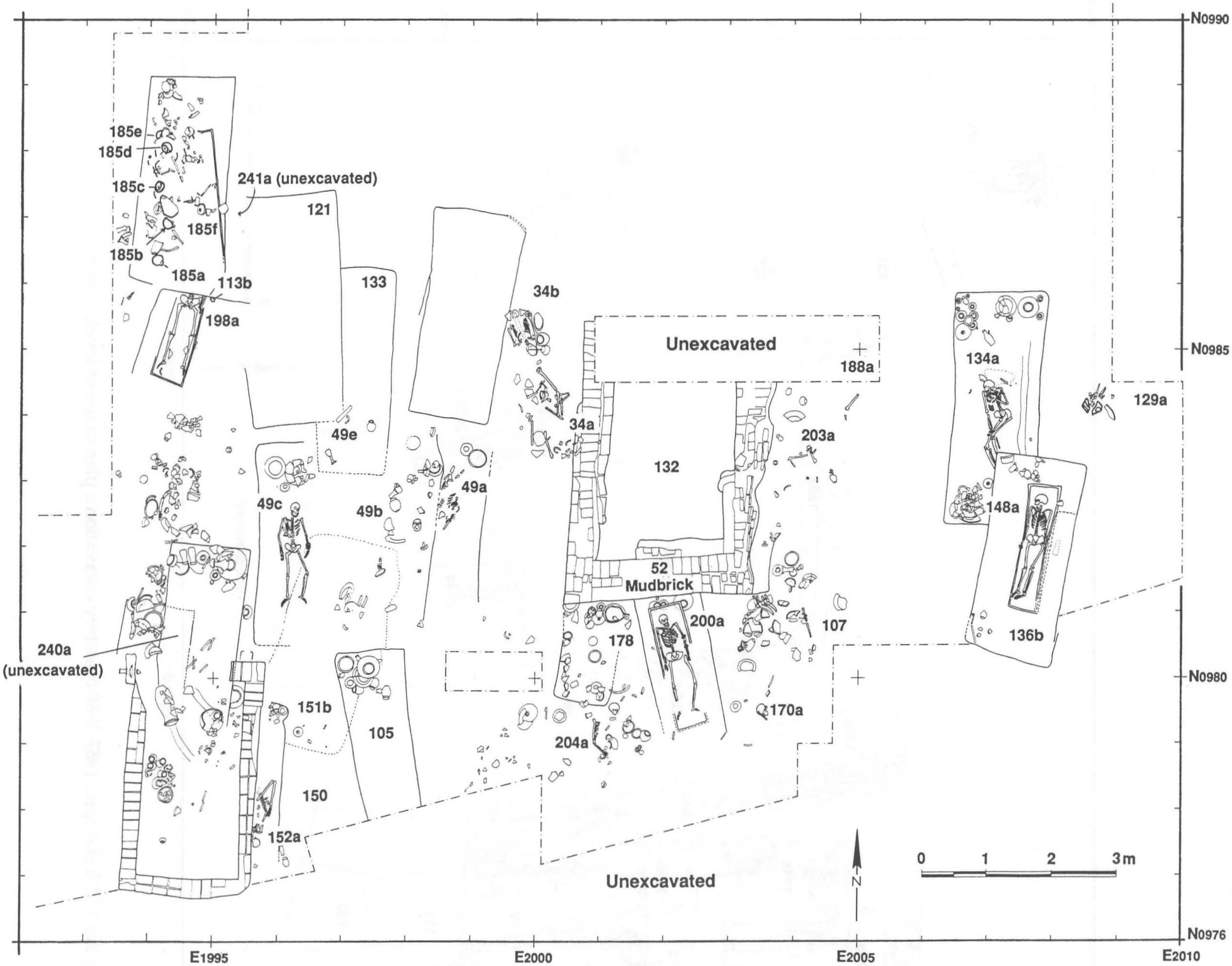

Figure 13.16: Harappa 1987-1988 cemetery excavations: plan of upper levels with feature numbers.

Figure 13.17: Harappa 1987-1988 cemetery excavations: plan of lower levels with feature numbers.

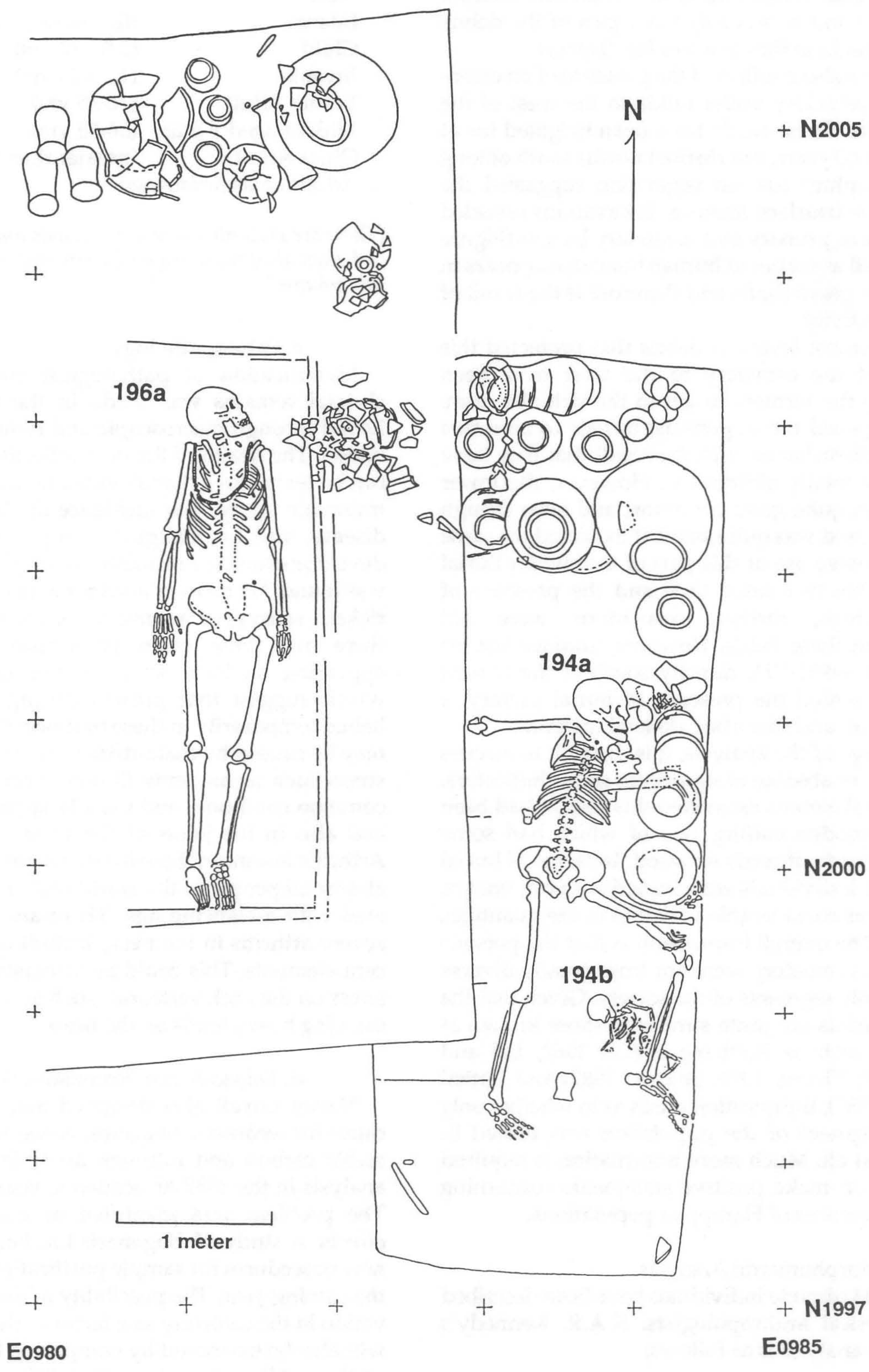

Figure 13.18: Harappa 1988 cemetery excavations: Burials 196a, 194a, and 194b (see also Figure 13.17).

surface, this bone is assumed to have been derived from the cemetery and is probably not a part of the debris that was brought to the cemetery for disposal.

Excavations also confirmed the presence of an extension of the cemetery under fields to the west of the protected site. These fields have been irrigated for at least the last 60 years, but distinct north/south oblong patches of lighter colored vegetation suggested the presence of subsurface features. Excavations revealed the presence of primary and secondary burials (Figure 13.19), as well as scattered human bone that appears in the fill of the grave shafts and therefore is the result of Harappan activity.

The uppermost levels of debris that protected this extension of the cemetery to the west have been removed by the farmers to get to the rich alluvium. This has exposed the uppermost burials to intensive plow zone disturbance with the result that they have been almost totally obliterated. However, the lower burials are in quite good condition, and even though the area exposed was quite small, it indicated the same type of intensive use of this part of the site for burial purposes. Due to limited time and the presence of standing crops, further excavations were not conducted in these fields. However, another test pit (E1968-1970, N951-952) directly south of the known cemetery revealed the presence of burial pottery, a copper mirror, and disturbed skeletal material.

At this stage of the analysis, it is difficult to discuss the presence or absence of significant status indicators. Some of the skeletons excavated this season had been buried in wooden coffins, two of which had some form of lid made of reeds or wood. In terms of burial goods, some individuals were buried with ornaments, and there was considerable variation in the quantities of pottery. The overall impression is that the persons buried in this cemetery were not from greatly diverse socioeconomic segments of the society. Given that the Harappa burials are quite similar to those known at other sites such as Kalibangan (Lal 1962; Lal and Thaper 1967; Thaper 1975; Sharma 1982) and Lothal (Rao 1979, 1985), the question arises as to whether only a special segment of the population was buried in cemeteries at all. Much more information is required before we can make positive statements concerning the burial practices of Harappan populations.

b. Morphometric Analysis

To date, 34 discrete individuals have been described by the physical anthropologists. K.A.R. Kennedy's preliminary analysis is as follows:

SEX	
Males	10
Females	17
Sex Uncertain	7

AGE		
Infant	(less than 3.5 yrs)	2
Child	(3.5 - 12 yrs)	1
Juvenile	(12.5-15 yrs)	0
Young Adult	(16-35 yrs)	18
Middle-aged Adult	(36-55 yrs)	11
Older Adult	(greater than 55 yrs)	0
Adults of uncertain age		2

[*These are preliminary determinations and have been modified since they were originally reported; see Chapter 11 in this volume.*]

c. Palaeopathology

Identification of pathological conditions of the skeletal remains was made in the field by Nancy Lovell through macroscopic and radiographic examination. The health of the new collection of Harappans can be tentatively characterized by a low incidence of traumatic injury, low incidence of chronic infectious disease, and no malignant neoplastic disease. One developmental abnormality, a scaphocephalic skull, was found. No cases of nutritional inadequacy, such as rickets, scurvy, or anemia were identified; however, there are three cases of arrested growth lines appearing on long bones (visible on radiographs), which suggest that growth during childhood was halted temporarily in these individuals. Growth arrest may be caused by malnutrition or other physiological stress such as an acute illness. Arthritis is the most common condition, and usually appears in the spine, and also in the joints of the knee, hands, and feet. Arthritic lesions in these locations are common among almost all people of the world and are usually associated with advancing age. There are several cases of severe arthritis in the neck, including fusion of adjacent elements. This could be associated with unusual stress on the neck vertebrae, such as would occur with carrying heavy loads on the head.

d. Palaeodietary Reconstruction

Nancy Lovell also designed and initiated procedures for reconstructing subsistence at Harappa using stable carbon and nitrogen analysis. The results of analysis in the 1987-88 academic year were spurious. The problem was identified as due to diagenetic effects. A study of diagenesis has been initiated, and new procedures for sample purification will be used in the coming year. The possibility of differential preservation in the cemetery as a factor in the isotope results will also be examined by comparing histological thin sections of bone from burials at different locations and depths within the cemetery. Most of the bone samples obtained in 1987 came from deposits that were closer

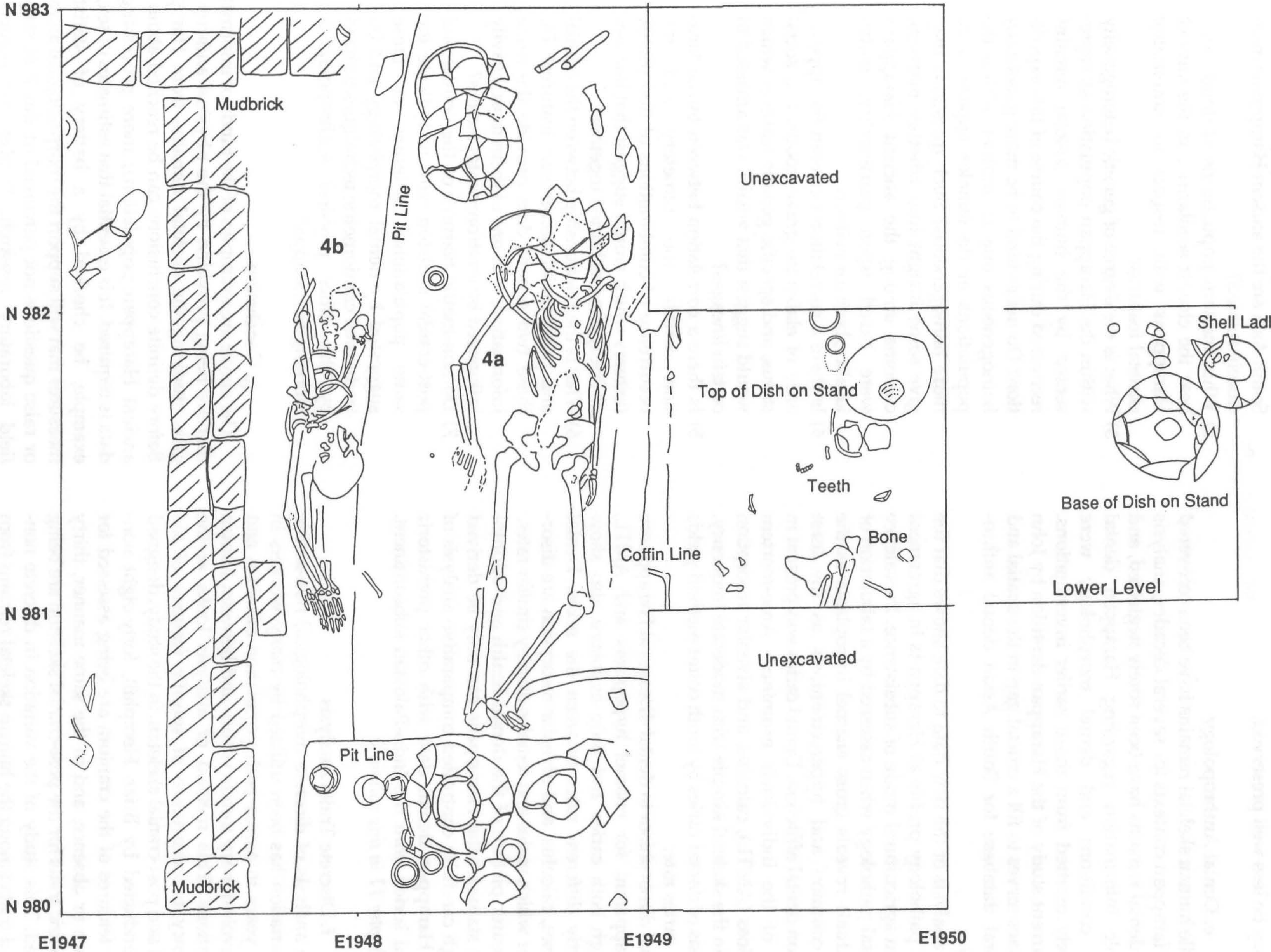

Figure 13.19: Harappa 1988 cemetery excavations: burials in fields west of area R37.

to the surface than those obtained in 1988 and therefore may be less well preserved.

e. Dental Anthropology

While human skeletal remains have been recovered from Harappan contexts for several decades, analysis of the dental remains have been sorely neglected, and valuable information regarding Harappan dental health conditions and dental morphology were routinely omitted from those earlier investigations. The current study of the Harappan dentition by John R. Lukacs serves to fill a crucial gap in the spatial and temporal database for South Asian dental anthropology.

The analysis of the new data to date shows that the dental pathology profile at Harappa is in agreement with an agricultural mode of subsistence. Prevalence of dental pathology when assessed by a tabulation of individuals reveals gross enamel hypoplasia as the most common and hypercementosis as the least common dental affliction. Dental caries was present in 43.6% of the individuals examined. Ante-mortem tooth loss (AMTL), calculus, and alveolar resorption occur in the skeletal sample with moderate frequency. Analysis of dental caries by tooth count method yields a 6.8% caries rate.

Sexual dimorphism in dental diseases at Harappa are most apparent for enamel hypoplasia and AMTL, although both caries and pulp exposure also show distinctly different rates between the sexes. Dental abscesses, calculus, and alveolar resorption are disorders for which males and females display similar rates.

A clearer picture of the dental health and odontometric status of the Harappans can only be derived through carefully controlled comparative analysis of these Harappan dental data with other prehistoric skeletal series from the Indo-Pakistan subcontinent. [*See Chapter 11 in this volume.*]

f. Discrete Traits Analysis

The analysis of discrete morphological non-metric trait variation has been utilized by many workers in recent years to assess both population affinities and microevolutionary trends within and between human populations. This method of analysis looks at the frequency of occurrence of specific features of the cranial and post-cranial skeleton. In the study, designed and conducted by Brian Hemphill, forty-eight non-metric features of the cranium are being assessed for presence or absence, and in the same manner, thirty non-metric traits for the post-cranial skeleton are being assessed. This study of the variation in discrete non-metrical traits among the human skeletal remains from Harappa is addressing the following seven questions:

1) To what other prehistoric populations from South Asia are the ancient Harappans most closely related?
2) What modern populations of South Asia bear the closest similarities to the ancient Harappans with respect to non-metric skeletal features?
3) What is the degree of genetic heterogeneity within the Harappan population as represented by the human skeletal remains recovered during the course of this expedition? Do males tend to be more genetically homogeneous one to another within the populations or do females appear to be more homogeneous? Such questions may give some insight into whether marriage customs among the ancient Harappans were based upon patrilocality, matrilocality, both, or neither.
4) Is there a correlation between the appearance of elaborate grave goods, i.e., social status, and specific genetic features which would suggest that wealth was amassed in certain lineages?
5) Is there a correlation between burial location within the cemetery and the occurrence of combinations of non-metric features which would suggest that families or lineages were buried together?
6) What is the relationship between the cranial and post-cranial non-metric features? Do these two sets of data provide the same information, or is one of them more heavily influenced by environmental factors?
7) Do non-metric features of the cranial and post-cranial skeleton tend to indicate the same populational affinities as those suggested by dental morphology and by traditional craniometric techniques utilized by the other physical anthropologists working at Harappa?

g. Conclusion

The above are examples of the kinds of information that are being provided by the physical anthropologists studying the skeletal remains from Harappa. Before definite conclusions can be reached about the ancient Harappan populations, more processing of data is required. It is essential that estimates of sex, for example, be checked by a battery of statistical measures that will support the morphological analyses or raise questions not perceived at this first stage of field laboratory research. Stature reconstructions, frequencies of pathological conditions, and other

features must be investigated using multivariate and regression statistics. [*See Chapter 11 in this volume.*] When these data are thoroughly analyzed, the physical anthropologists should be in a better position to define the biological affinities, diversities, and characteristics of at least that segment of the ancient Harappa population represented in the Harappan phase cemetery excavations.

2. Mound AB, Deep Sounding

During the third season, we resumed excavations in the large erosion gully on Mound AB. Because of the presence of well-preserved fired brick floors, drains, and walls discovered last season along both edges of the gully, the focus this season was in the large flat area in the center of the gully. Directly in the center of the mud-brick area, the top of a well constructed with fired brick was discovered (Figure 13.20). With the exception of a few bricks missing from the top rings of the well, the structure was found to be in excellent condition. It was constructed of wedge-shaped bricks, each marked with a pair of incised vertical lines on the outer surface. Since such markings are not known on other well bricks at Harappa, it is possible that the markings were used to identify bricks to be used for making this well alone. The interior diameter of the well is 1.20 meters and each ring consists of 36 bricks each 26 cm long.

The interior of the well was cleared to a depth of 5.9 meters from the existing top layer of bricks, i.e., from 168.78 to 162.87 AMSL (Figure 13.21). The upper half of the filling consisted mainly of Late Harappan (Cemetery H) pottery sherds, while the lower part contained Harappan brick fragments and sherds. The bottom of the well was not reached. The lower walls started to crack and bulge in as the interior filling was removed and a new pattern of stresses on the structure was created. Excavations in the well, therefore, were halted, and the top was sealed for purposes of safety.

Outside the well, a tall vertical section was cleared against its northern exterior to investigate its construction. The well, which can be dated sometime late in the Harappan phase, appears to have been constructed by first excavating a large pit in the center of the mound cutting through earlier habitation layers and domestic debris. This interpretation, however, requires further testing.

Our original goal of reaching natural soil in this area of excavation was thwarted by the discovery of intact and extensive Harappan architectural remains, which are important in themselves as they represent one of the few areas on Mound AB that has undisturbed Harappan architecture.

3. Mound E

a. Exploratory Trenches

Excavations on Mound E were begun during the second season, but major exposures were not started until the third season. The excavation areas were selected on the basis of surface indicators such as architectural features, surface topography, and artifact concentrations. Three distinct areas were excavated: the northwestern slope, the top of the northwestern corner of the mound, and the southwestern slope.

The excavations on the northwestern slope consisted of a major step trench oriented east-west and extending from the crest to the base of the mound (Figures 13.22, 13.23, 13.24, 13.25, 13.26). Additional areas were exposed to the north and south of the step trench to delimit architectural features and special activity areas. The total excavated area on the slope is 181.5 square meters, with the depths of the excavations ranging from 50 cm to 6 meters.

On the top of the mound, similar test trenches were begun and then expanded. Four distinct trenches were opened totaling 116.5 square meters, with an average depth of 2 meters.

The excavations on the southwestern slope were conducted in a 4 × 6 meter area (24 square meters) where baked brick walls were seen eroding from the mound.

The results of these different excavations revealed the presence of three major periods of occupation. In the lowest levels, the earliest occupation of the site is represented by hearths and possible mud-brick architecture of the Early Harappan phase (Figures 13.25 and 13.26). These levels are overlaid by deposits that contain artifacts and pottery that may reveal the nature of the transition from the Early Harappan to the subsequent Harappan occupation. Most of the trench reveals remains of the Harappan habitation of the mound (Figures 13.22, 13.23, and 13.24). These deposits comprise several phases of major architectural activity representing the construction of what appear to be massive mud-brick revetments and platforms at the edge of the mound. Some of the platforms are reinforced by baked brick revetment walls.

Although the detailed analysis of the stratigraphy is still underway, it seems that the edge of the mound was used for both craft activities (pottery manufacture) and habitation. The uppermost levels of Harappan occupation are followed by strata containing pottery of the Late Harappan (Cemetery H) phase. Again, the pottery styles suggest that there may be a transitional period between the Harappan and the Late Harappan phases. Future excavations in this area of the mound and the final analysis of the artifacts and pottery will

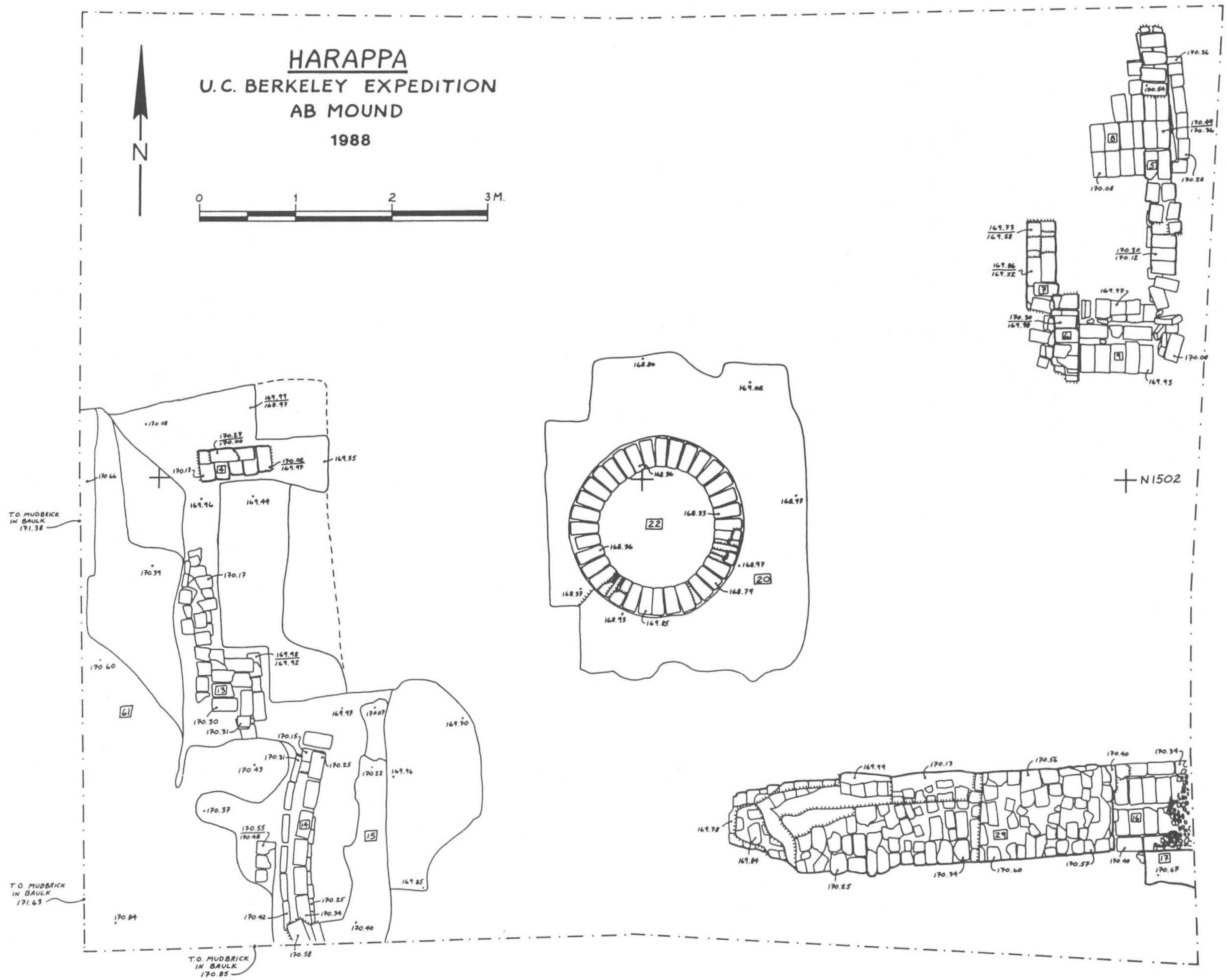

Figure 13.20: Harappa 1988: Mound AB, Operation 2: plan of excavations.

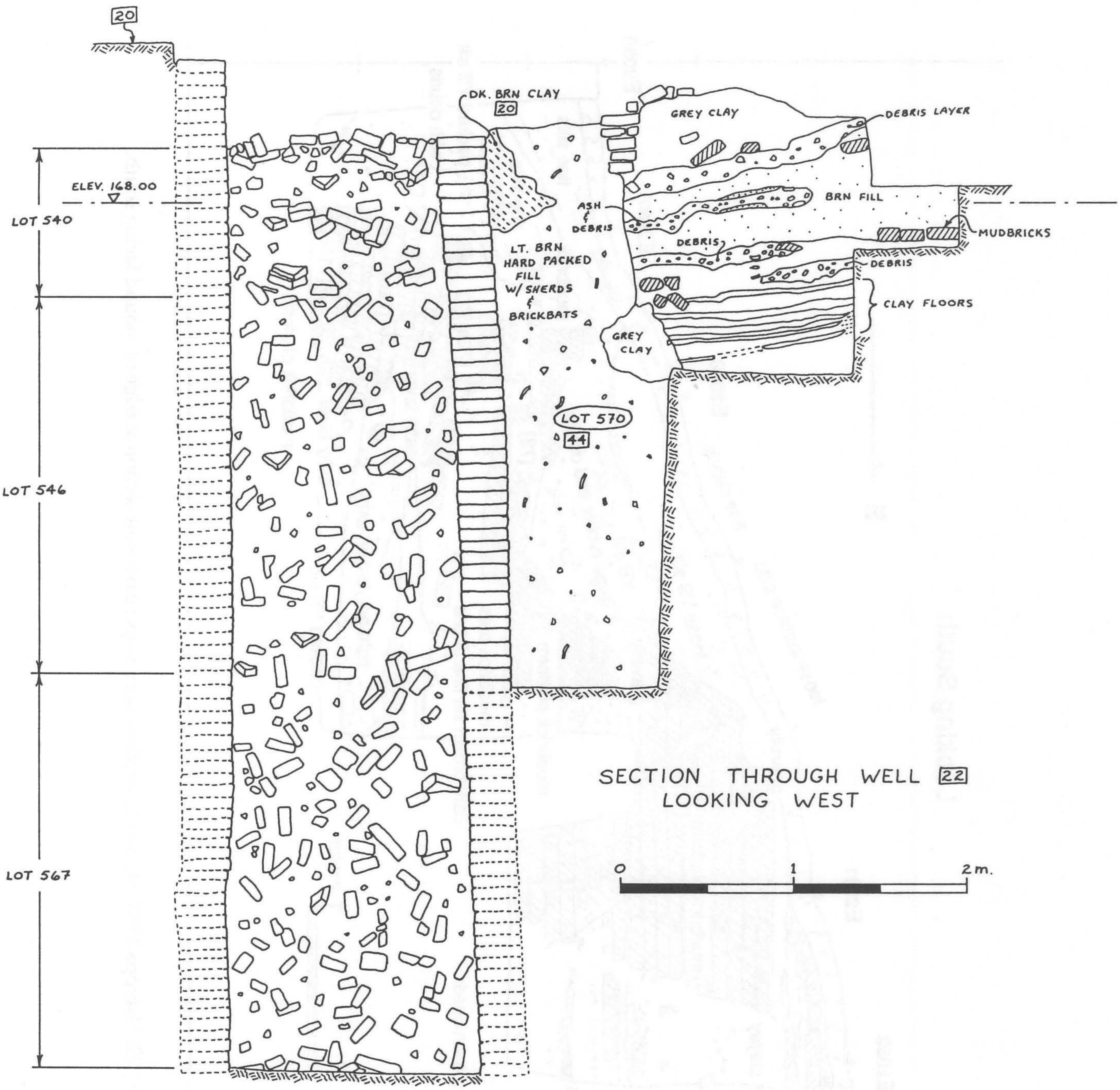

Figure 13.21: Harappa 1988: Mound AB, Operation 2: section through well #[22] facing west.

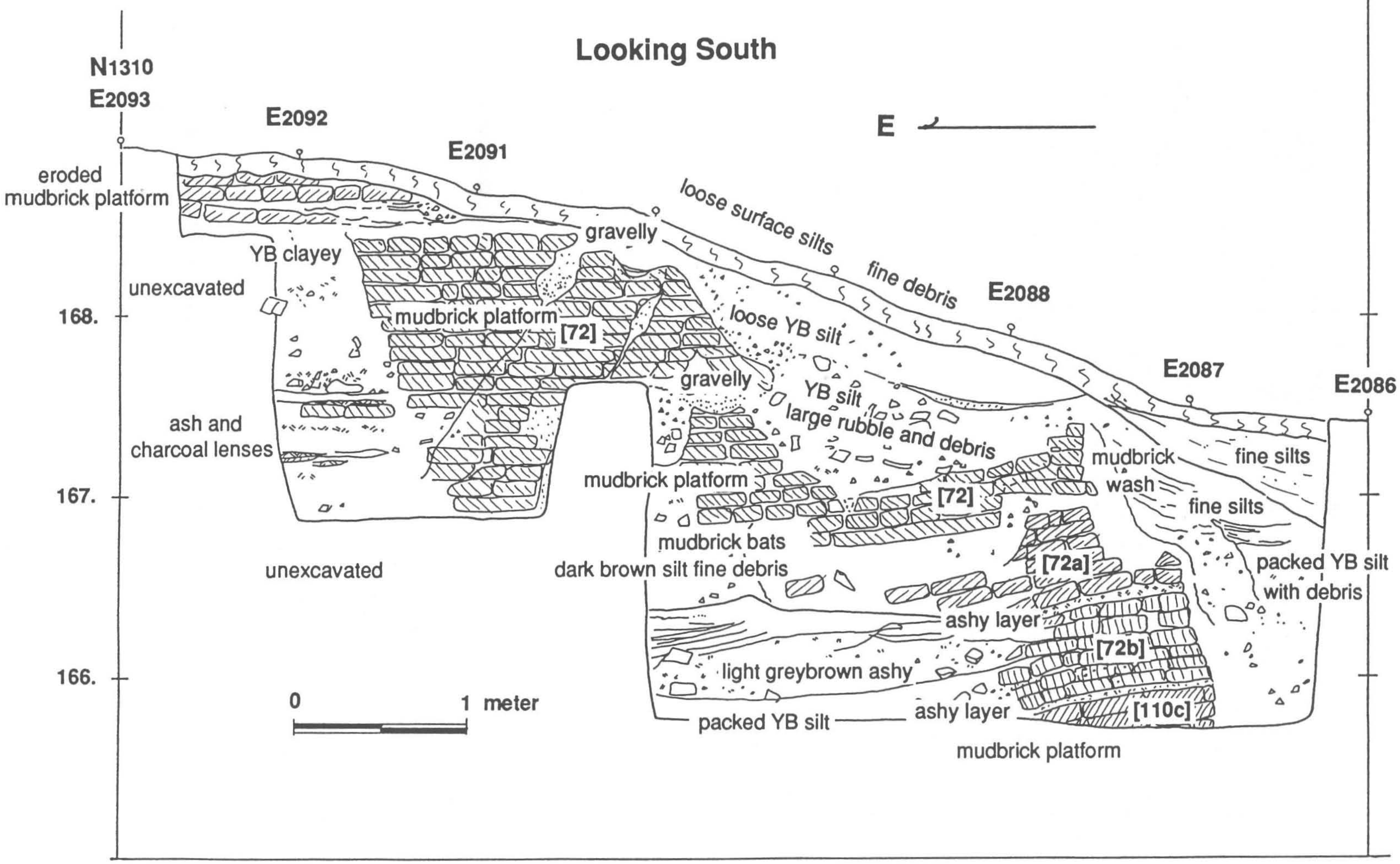

Figure 13.22: Harappa 1988: Mound E, northwestern slope: east-west section at edge of mound facing south.

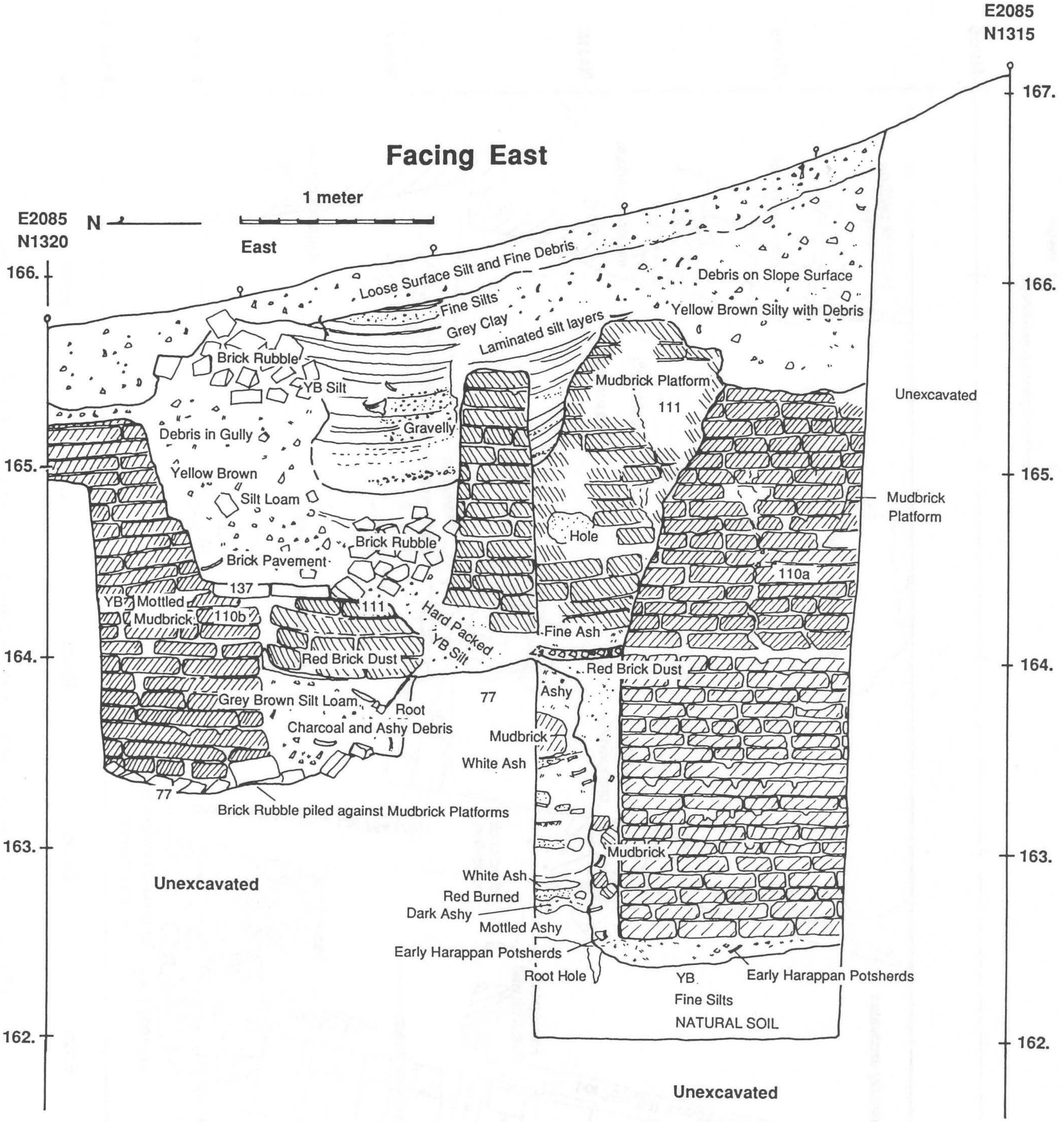

Figure 13.23: Harappa 1988: Mound E, northwestern slope: north-south section facing east showing platforms.

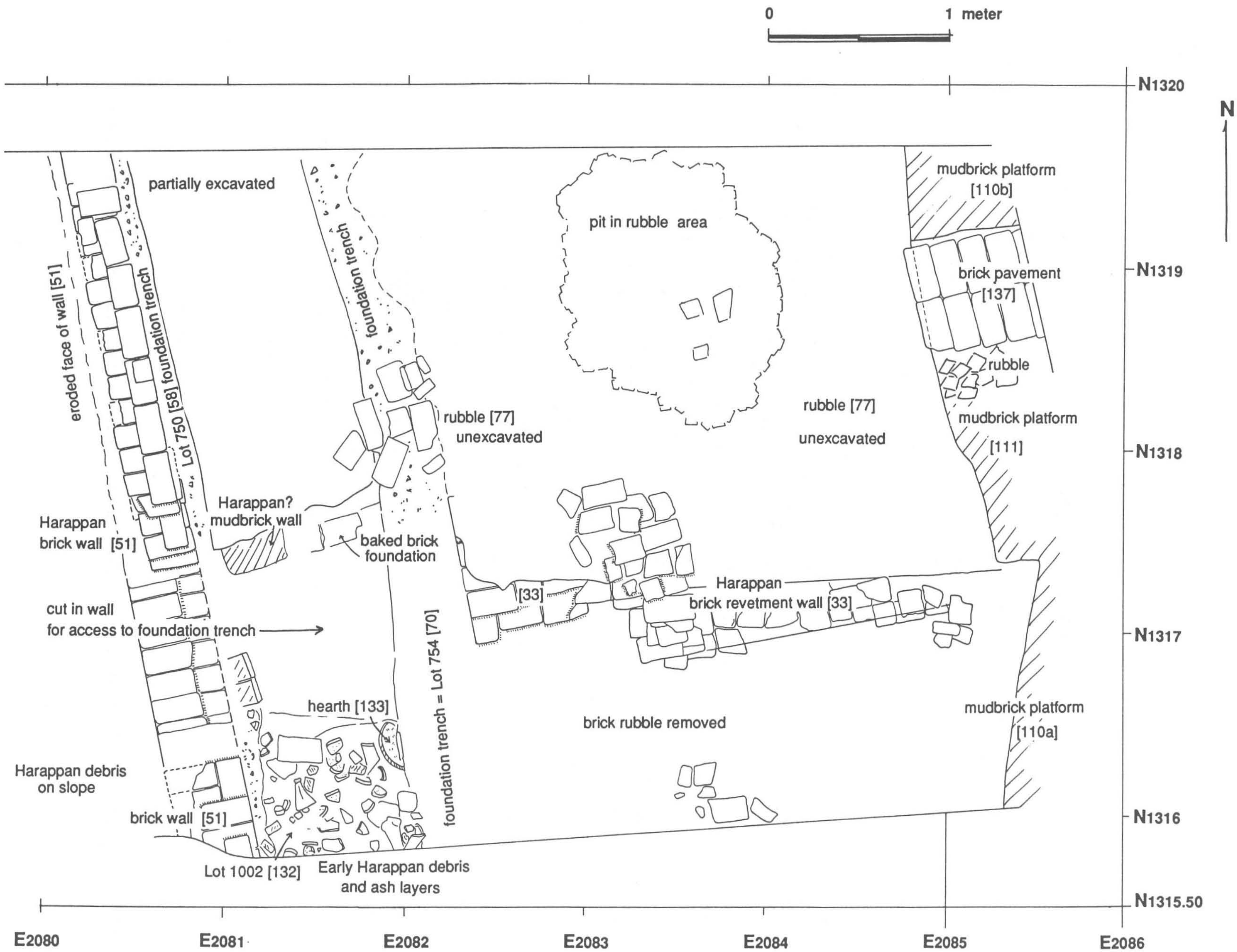

Figure 13.24: Harappa 1988: Mound E, northwestern slope: plan view of walls and revetment.

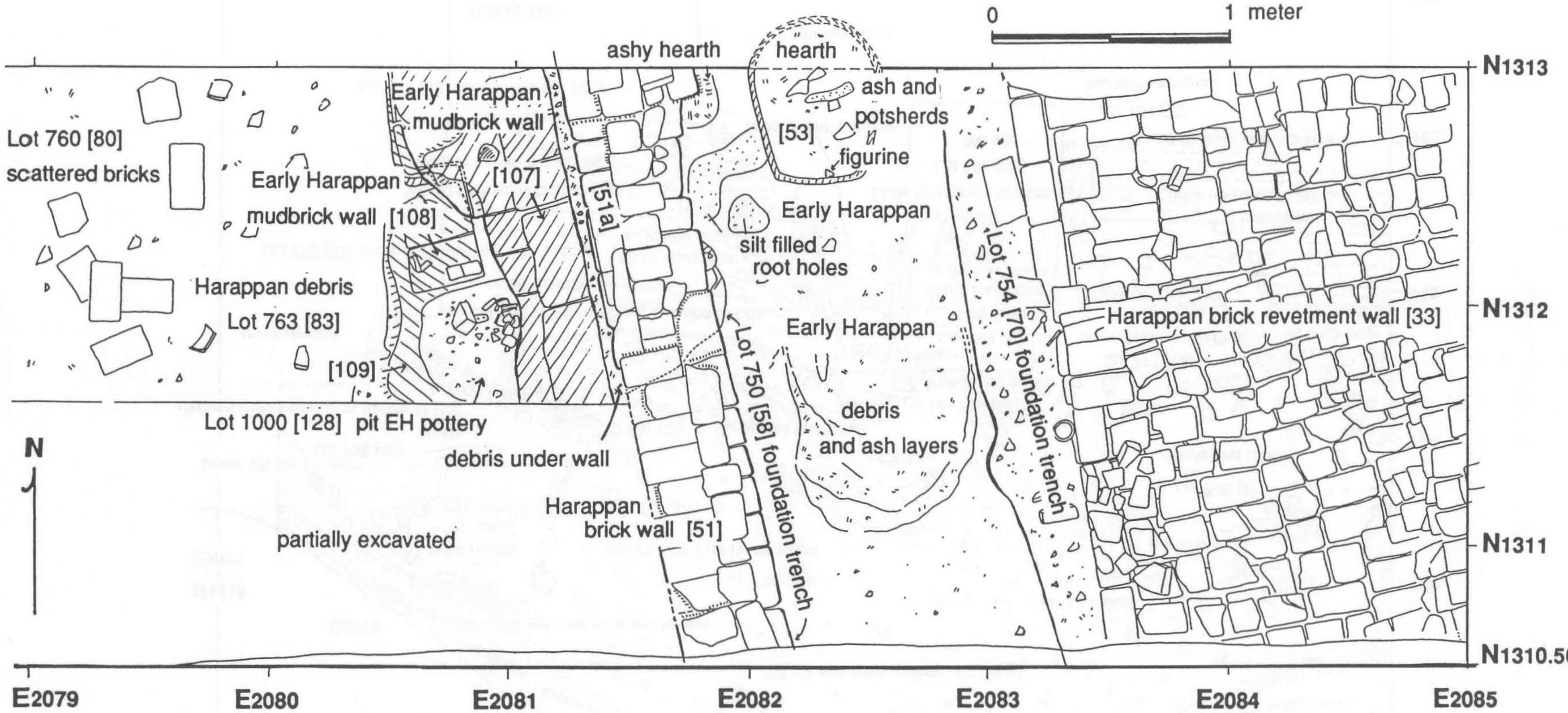

Figure 13.25: Harappa 1988: Mound E, northwestern slope: plan view of walls and revetment.

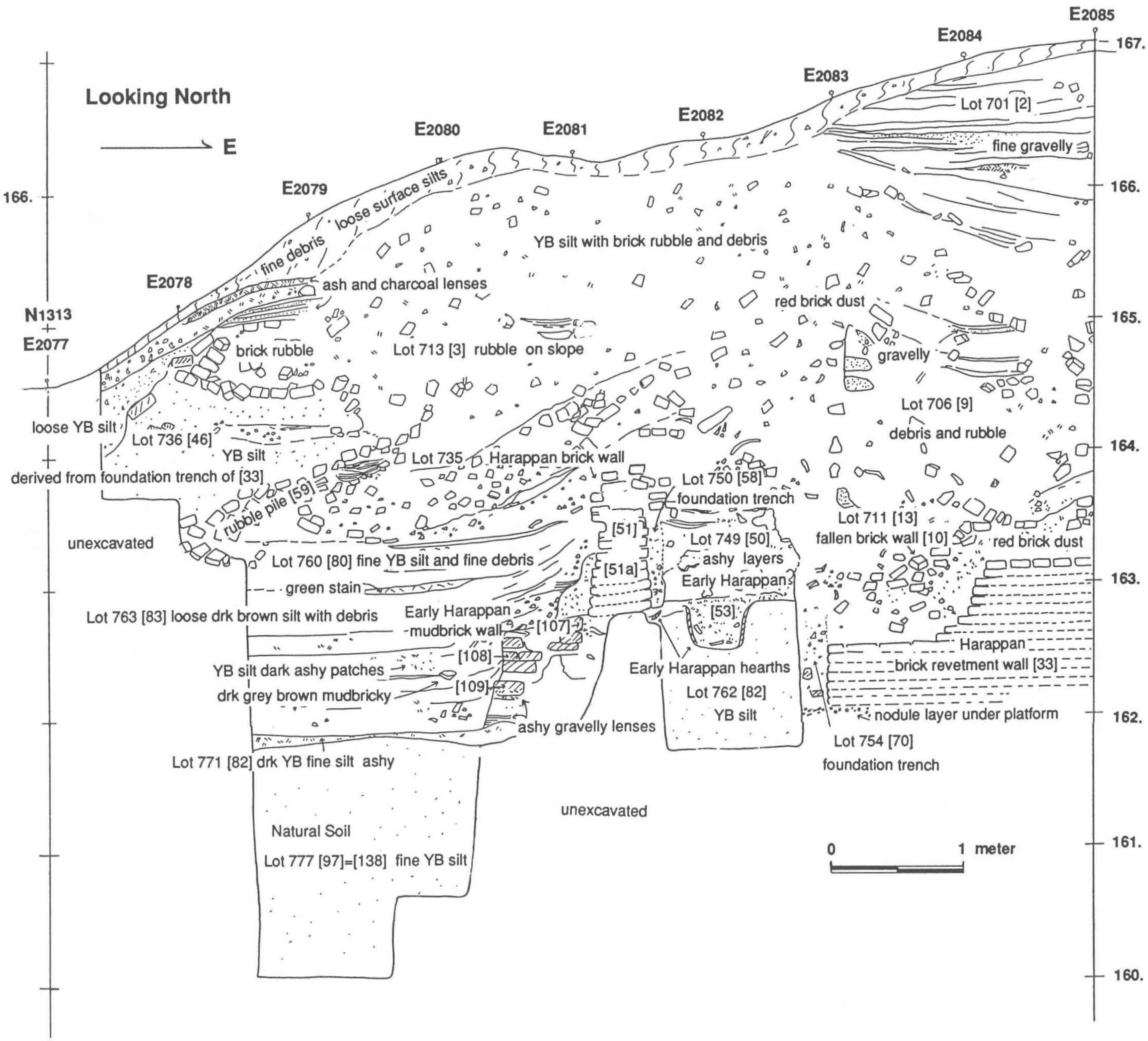

Figure 13.26: Harappa 1988: Mound E, northwestern slope: east-west section at edge of mound, facing north.

provide a new understanding of the cultural sequences that are represented on Mound E.

The excavations on Mound E represent only a small portion of the mound, and yet they have revealed some important new features that may change our perception of how the Indus cities were built up. The step trench revealed successive platforms or revetments and foundations of mud-brick combined with baked brick, extending from the base of the mound, right to the top. These mud-brick structures were not built at one time, but are the result of many separate phases of construction (Figure 13.22).

The latest platforms are at the top of the mound and are associated with Late Harappan, Cemetery H, type pottery. These platforms overlie "mature" Harappan structures that include habitation, kitchen, and domestic dump areas.

Beneath these latest Harappan structures are earlier mud-brick platforms that overlay a series of eroded and reconstructed platforms. The mud-brick platforms and retaining wall appear to have been strengthened by a baked brick revetment or facing (Feature #[33] in Figures 13.24, 13.25, and 13.26). Traces of this baked brick revetment (#[33]) have been found to the west of the mud-brick revetment wall. This structure was about 2 meters wide at the base, with a sloping exterior face. Based on calculations of toppled courses of brick, it is estimated that this baked brick facing stood some 3 to 4 meters high from natural soil to the crest of the mound. Similar structures found by Wheeler on Mound AB were interpreted as a defense wall. Further excavations will be conducted to clarify the function of this massive brick structure. It will then be essential to make detailed comparisons with Mohenjo-daro where the German research team is suggesting that the construction of massive platforms was an intentional first stage in site construction (Jansen 1987; Leonardi 1988).

An earlier north-south wall of baked brick (Feature #[51]) has been found approximately 75 cm farther to the west of the large baked brick structure (Feature #[33]—Figures 13.24, 13.25, and 13.26). This wall has been traced for some 25 meters, and it too is oriented in correspondence with the structures exposed by Wheeler on Mound AB. The long wall appears to have been rebuilt at least once, and the western face is badly eroded. This suggests that the eastern face was covered with earth, while the western face was exposed to water erosion and salt damage by seepage and evaporation.

Beneath this baked brick wall are earlier mud-brick structures that were not completely exposed during the 1988 season (Figure 13.26). They may represent earlier mud-brick walls that were replaced by the baked brick wall, or they could be unrelated structures that were demolished to build the long brick wall. The ceramics associated with these earlier mud-brick structures are characteristic of the Early Harappan phase as defined by M.R. Mughal on the basis of material from Kot Diji and Jalilpur (Mughal 1970, 1974). There has been some ancient mixing of the strata due to the fact that the Harappans dug into these early levels to construct their baked brick structures, but we were able to locate some undisturbed Early Harappan strata associated with primary context hearths containing charcoal. These lie directly on top of natural alluvium. Some of the Harappan structures that have cut entirely through the Early Harappan levels are also lying directly on top of natural soil (Figure 13.26). Test pits were sunk to a depth of one meter below the top of the natural soil, and deeper corings were made to confirm the fact that this is natural sediment.

In summary, the step trench on the northwestern face of Mound E provides a continuous sequence of habitation and construction from the Early Harappan ("Kot Dijian") occupations on natural soil through the Harappan to the Late Harappan ("Cemetery H") occupations on the top of the massive mound. In addition to the masses of pottery, figurines, terra-cotta bangle fragments, and other artifacts, we have been able to collect a wide selection of faunal materials, soil samples for palaeobotanical studies, and most important, clusters of carbon samples for radiocarbon dating.

b. Pottery Kiln

In addition to the large step trench, a 5 × 5 meter area associated with vitrified kiln wasters was excavated on the northwestern slope of Mound E (Figure 13.27 and 13.28). The Harappan strata are characterized by many sequential layers of floors with red burned patches and no ash. These are interpreted as working floors that have been periodically cleaned and flattened. The precise pyrotechnological activity has not yet been determined and will require some additional excavations.

Beneath these burned floors, are the remains of a large updraft kiln that appears to have been used to fire pottery and other ceramic objects (Figure 13.28). It does not appear to have been used for metal smelting. The terra-cotta vessels, bangles, and figurines found in association with the kiln have been collected very carefully, with detailed recording of provenience and micro-stratigraphy in order to reconstruct the process of site formation and erosion associated with the use and abandonment of the kiln.

In addition to the ceramic artifacts, these strata contain worked antler and bone, a mass of botanical information in plant impressions, charcoal pieces, and ash. Soil samples for pollen analysis have also been collected from all major stratigraphic units, providing

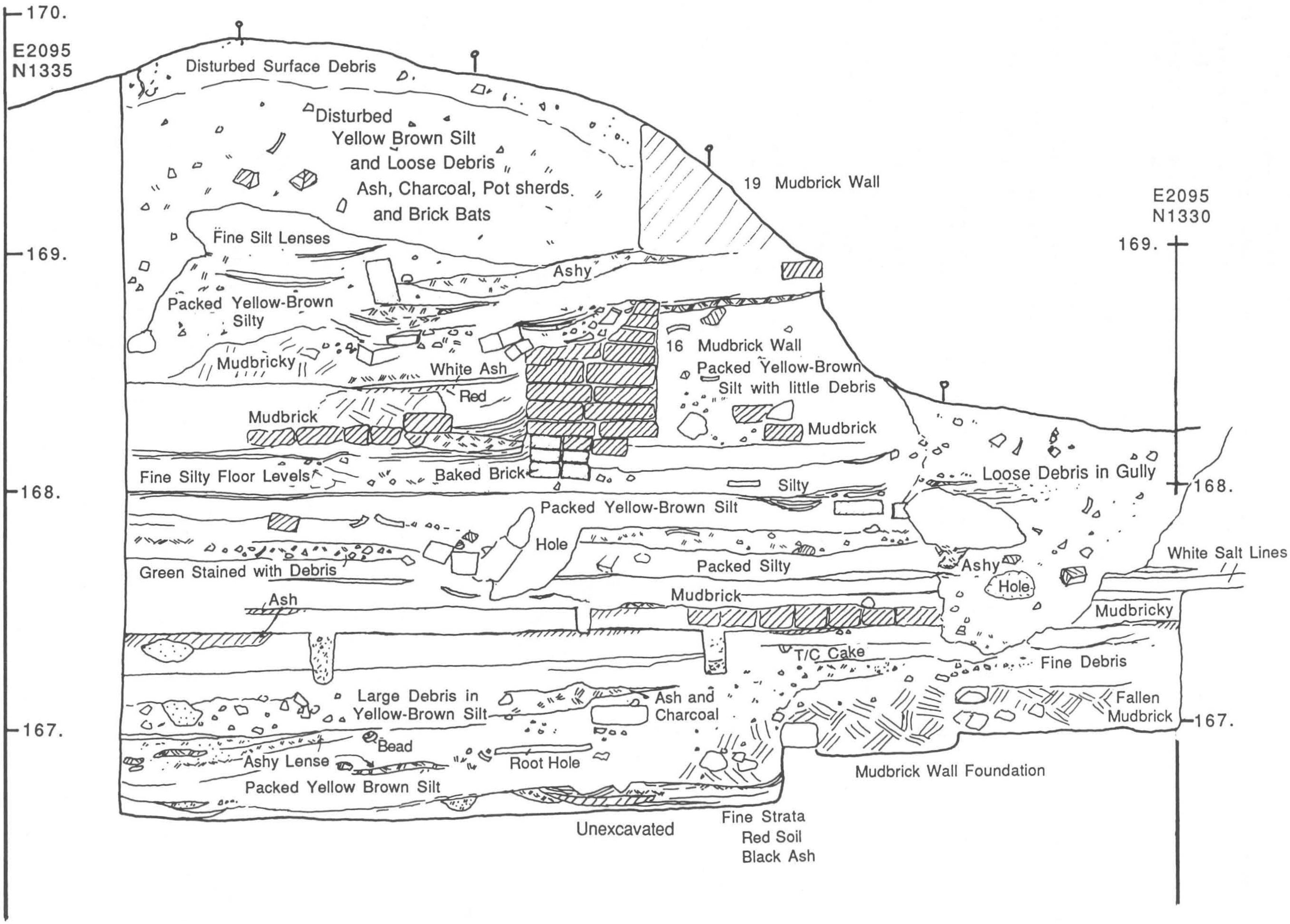

Figure 13.27: Harappa 1988: Mound E, northwestern slope above kiln: north-south section, facing east.

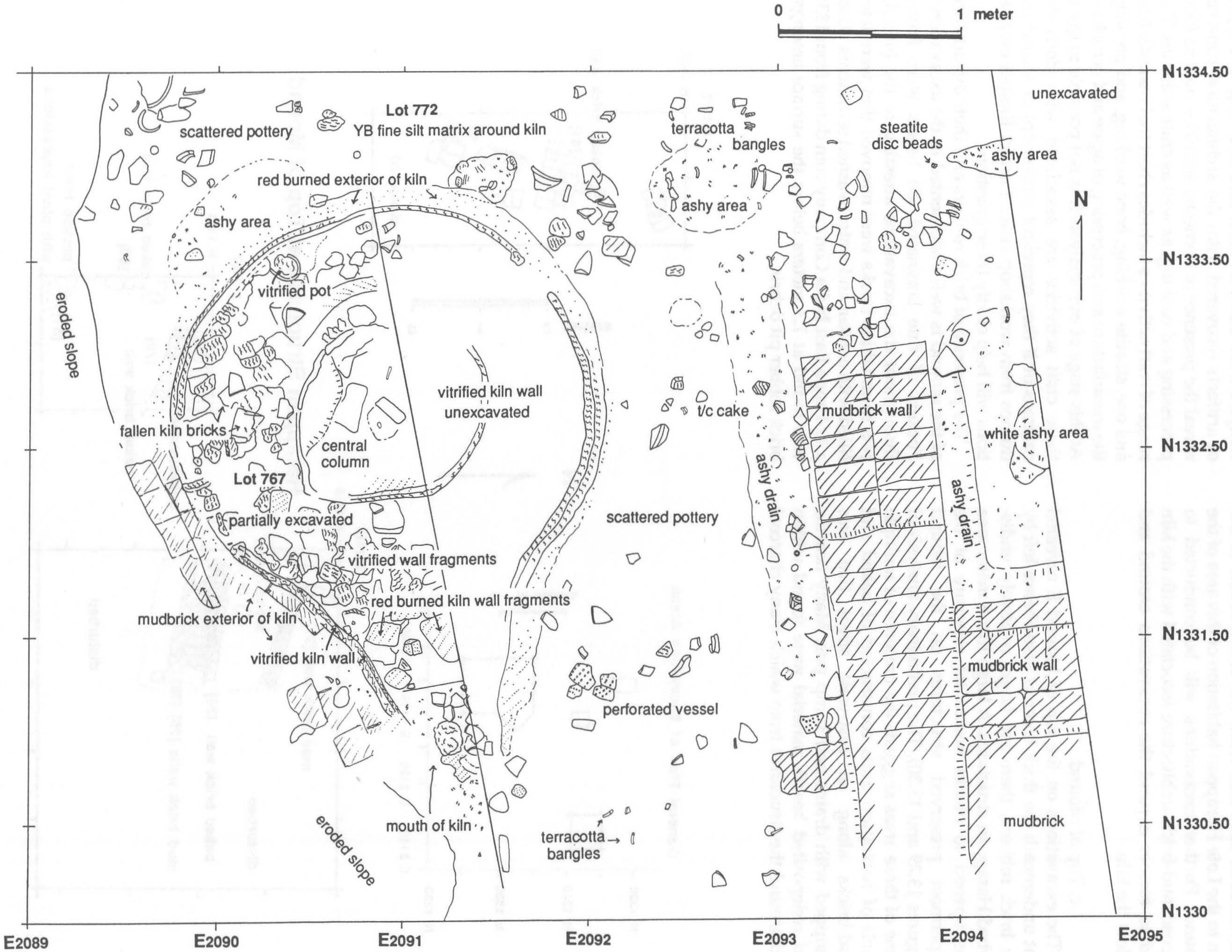

Figure 13.28: Harappa 1988: Mound E, northwestern slope: plan of kiln area.

a continuous sequence from the construction of the kiln to the Late Harappan habitation of this area of the mound. Further excavations will be conducted to expose mud-brick architecture associated with the kiln and to further expand the excavations around and below the kiln.

c. Top of Mound

The excavations on the top of Mound E revealed that underneath the thick layer of disturbance left by the brick robbers, there are large, relatively undisturbed Harappan structures. A large 10 × 8 meter area was opened to obtain horizontal exposure of the uppermost preserved structures on the mound (Figures 13.29 and 13.30). The preliminary analysis of some of these areas suggests the presence of multiple levels of habitation units constructed of baked and mud-bricks along an east-west street that was equipped with drains and sump pits. Many hearths and redeposited hearth material were found within and around the structures from which many charcoal samples were taken for radiocarbon dating. The types of artifacts recovered from the architectural contexts reveal the presence of domestic activities such as food processing and cooking, as well as craft activities. The range of craft activities includes chert tool manufacture and use, steatite working, bone working, and possibly the manufacture and processing of agate and carnelian. At this stage of our analysis it is not possible to say if these craft activities are associated with domestic contexts or if they represent workshops or secondary dumps from workshop areas. Further limited excavations will help clarify these questions.

The presence of brick robbers and their disturbance of the mound is well documented in the excavations. Pockets of fine laminated silt bands were found throughout the excavations attesting to the historic pits from which bricks were removed that were later filled with aeolian and water-washed sediments. Also, a 1/4 anna East India Company coin dating from 1835 was found at 1.3 meters below the surface amongst brick robber pit debris.

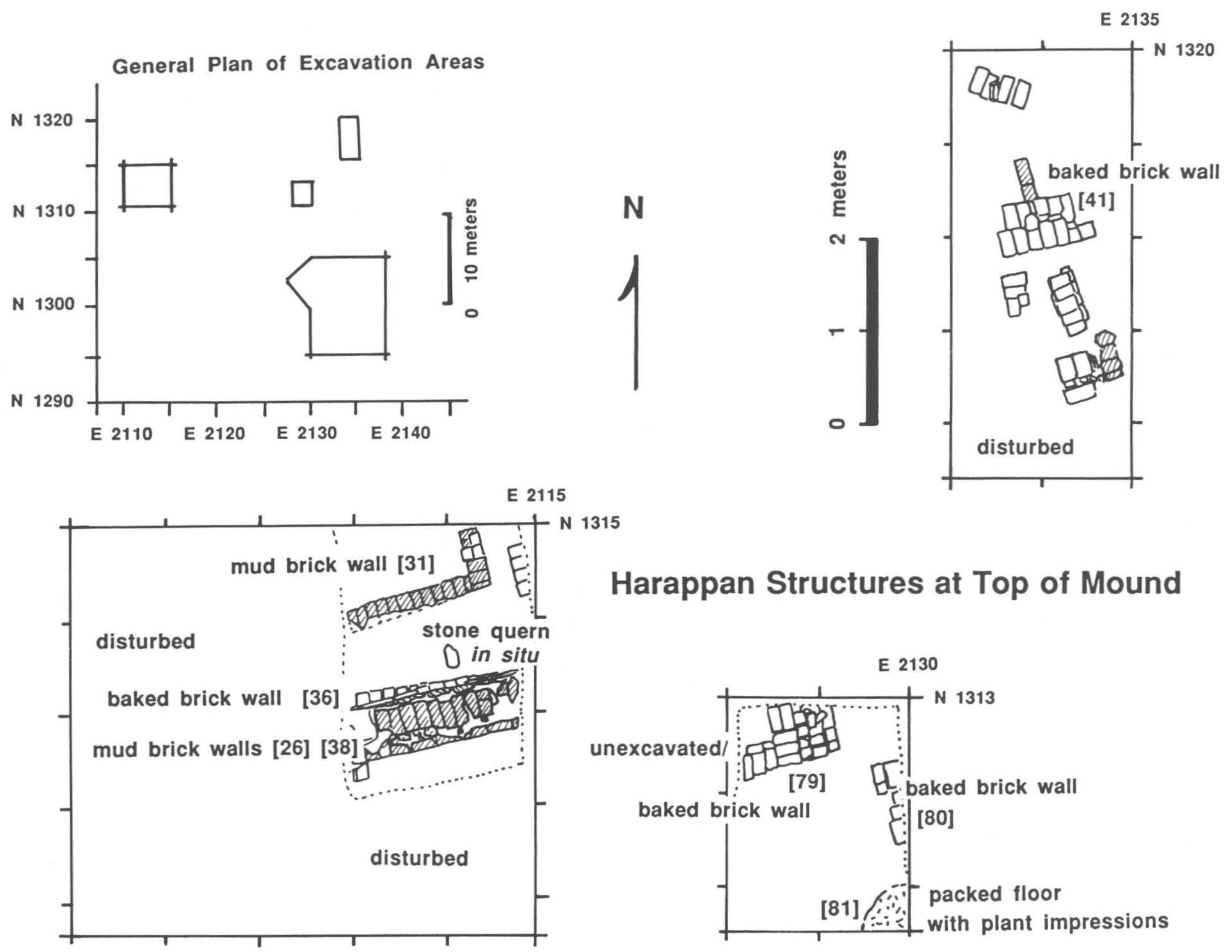

Figure 13.29: Harappa 1988: Mound E, northwestern corner on top of mound: plan of Harappa structures.

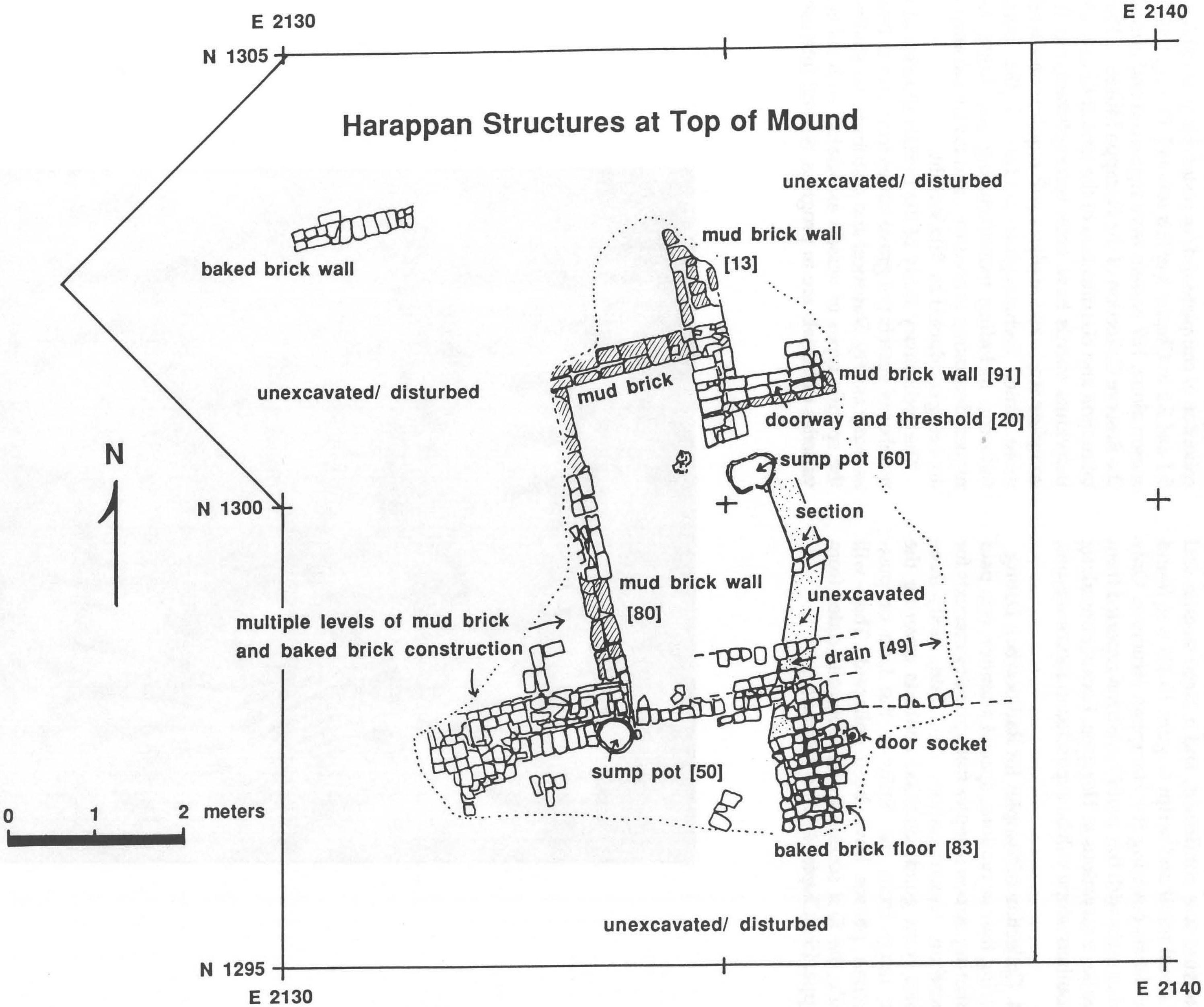

Figure 13.30: Harappa 1988: Mound E, northwestern corner on top of mound: plan of Harappan structures.

The third area of Mound E investigated this season was the southwest slope where earlier surface surveys had noted fired brick walls. Due to limited time and personnel, only one week of excavation was undertaken, but the presence of fragmentary Harappan architecture was confirmed, and a large steatite seal with a bull motif and script (Figure 13.31) was found in the debris covering the Harappan structure. Only six other seals with this motif have been reported from the earlier excavations at Harappa. Excavations along this southern slope will be expanded in future seasons.

4. Collection of Samples for Radiocarbon Dating

During the excavations, special attention was paid to gathering carbon samples from primary contexts for radiocarbon determination. To date, sixty-three samples from good stratified contexts covering the entire range from the Early to the Late or post-Harappan phases have been collected. They will provide the first series of archaeometric dates from Harappa. [*See Chapter 4 in this volume.*]

5. Studies of Specific Artifact Categories

a. Pottery

At Harappa, pottery is the single largest category of artifacts, as it is at all sites of the Indus culture. The Harappan cemetery excavations yielded a splendid collection of complete and/or restorable vessels [*Figures 5.1 and 5.2 in Chapter 5 of this volume*]. During the 1988 season alone, 169 vessels were registered and added to the Reserve Collection of the Harappa Museum. Partial tabulation and classification of the tens of thousands of individual sherds have been accomplished, but their complete study and analysis will require considerably more time. Technological studies of the pottery industry, including manufacturing and firing techniques, decorating procedures, and functional analysis, are being conducted by Rita Wright.

The preliminary study of the burials shows that the number of vessels per grave varies from one or two to as many as fifty. Statistical and distributional studies of the specific types of vessels associated with different varieties of burials are in progress. Several interesting

Figure 13.31: Harappa 1988: Bull seal from southern edge of Mound E.

details, however, have been noted. For example, although the vast majority of the pottery from the burials appears to have been unslipped and unpainted, there have been instances during the excavations when faint traces of applied colors have been detected on the surfaces of vessels but which vanish almost immediately after exposure to the drying effects of the air. Our conservation staff has been working on methods to preserve these fragile traces at least long enough for them to be documented properly. For example, during the third season, certain vessels, especially those in burial excavation Lot 219, were found to be covered with a thick white encrustation that appeared to be original decoration and not just a natural surface deposit. Laboratory tests showed the surface material to be gypsum. These coatings are extremely fragile and subject to dissolution during the vessel desalinization procedure. The procedures were modified to assure better preservation of these delicate surfaces.

The pottery and sherds from the other two excavation areas are providing new information of a very different nature. From the excavations on Mound AB and Mound E, sherds of both the Early Harappan and the Late Harappan (Cemetery H) phases have been collected from stratified contexts. They are being classified and described using the same basic methods used for the "mature" Harappan pottery so that consistent comparisons can be made among the three groups. This will provide an important corpus of new material relating to the questions of the antecedents and descendants of the Harappan phase populations.

b. Figurines

Of the figurines collected and tabulated during the third season, 54% are anthropomorphic and 46% are animal including a few bird forms. About 70% of these figurines came from Mound E. The second highest proportion, about 22%, came from the thick debris deposits covering the cemetery area but not from the graves.

The animal figurines (Figure 13.14) are especially difficult to identify to species. The bodies and legs of most quadruped mammals including non-humped cattle, buffalo, sheep, and even dogs are so stereotyped that they are often identical. It is usually other details such as distinctive horns, or the lack of them, that distinguish specific species. The detailed study of these figurines is being done in conjunction with faunal studies by our zooarchaeologist, Richard Meadow, who is setting up specific criteria for their identification.

The preliminary study of the anthropomorphic figurines (Figure 13.15) indicates that females are far more numerous than males, varying from more than 4 to 1 during the first two seasons to more than 7 to 1 in the 1988 season. The standing female figures are characteristically nude except for a hip belt that hides the pubic area. Elaborate headdresses and necklaces are usually added. It remains to be seen whether the different types of such ornamentations designate different functions for the individual figurines or whether they are simply *ad hoc* stylistic preferences.

The questions of overall significance and function of the figurines remains one of the basic problems. None have been found yet in archaeological contexts that provide clues to their use. However, there are certain varieties of female figures, such as those depicting food preparation and other domestic activities, that suggest mundane functions rather than that of Mother Goddess figures for at least some of the female representations.

Male figurines are depicted as entirely nude with an occasional simple necklace or headband. A few examples are ithyphallic, suggesting a fertility function, but others are in poses that do not appear to be ritualistic. Currently, the study of all the categories of figurines is focusing on the detailed description and analysis of typological and stylistic features and on the manufacturing techniques involved in their production.

c. Other Specialized Crafts

Samples of raw materials and of manufactured objects such as faience bangles and beads, stone beads, stoneware bangles, and metal objects have been collected for laboratory analysis. Manufacturing procedures are being studied in the laboratory, as well as through experiments, to actually replicate the techniques.

B. *Palaeoenvironmental Studies*

1. Palaeozoological Studies

The animal remains, bones and teeth, provide a major body of data for reconstructing the ancient environment and the human response to and use of it. Large quantities of faunal remains have been collected during the first three years of the Harappa project. This season, Richard Meadow continued his analysis, concentrating on samples from the fill overlying the Harappan cemetery. Faunal remains from these levels are plentiful and recovery from the screened sample pits is excellent, but the bones are highly fragmented and thus time-consuming to analyze.

Almost 1800 specimens were recorded. Of those, 231 were used to calculate the percentages of different forms represented in the collection. Some 41 percent come from sheep or goat and 48 percent from cattle or water buffalo, although only two bones of the last were positively identified. Among the 33 caprine bones identified as sheep or goat, 94 percent are from sheep, confirming the observation made on the basis

of last season's analysis that goats appear to be poorly represented at Harappa. Finally, 10 percent of the remains are from wild mammals including large and small deer, nilgai, boar, and blackbuck, and one percent are from dog.

As work continues on the faunal collection from Harappa, material from specific areas of the site will be examined in relation to its archaeological context and compared to that from other areas and other time periods in order to determine if there is variation through space or change through time in the exploitation of different kinds of animals.

2. Pedological and Palaeoclimatic Studies

Amundson and Pendall returned to Harappa to continue their field studies. [*For detailed reports on these studies see Pendall (1989); Pendall and Amundson (1990a, 1990b); and Chapter 3 in this volume.*] Attention this season was directed toward studying the soils and sediments within the site that are associated with excavated areas. Chemical analyses of soil samples and grain size analyses are being used to distinguish natural from archaeological deposits as well as to study the environment of deposition (e.g., whether the sediments were deposited in still or moving water, by wind, or by human action). Samples were collected from stratified profiles, walls, floors, hearths, and mud-bricks in order to permit characterization of these kinds of contexts.

Pendall conducted a soil survey of an eight square kilometer area around the archaeological site and the modern town of Harappa. Auger borings placed at 150 to 200 meter intervals along north-south and east-west transects were described in the field to a depth of 150 to 300 centimeters according to the Soil Survey Manual. Described were: the soil Munsell color, texture, consistency, presence; description of carbonate nodules (*kankar*) or seams of calcite, gypsum, and other soluble salts; and depth to parent material or water table. Soils with similar properties were grouped together as mapping units and classified according to the USDA Soil Taxonomy. A soil map was prepared using a topographic map of 1:50,000 scale as a base [*Figure 3.4 in Chapter 3 of this volume*].

The survey of the natural soil surrounding Harappa shows a dynamic and youthful environment because the meandering of the river Ravi has caused aggradation of the floodplain. The youngest geomorphic surface in the area is the lowest channel north of Harappa city and mound. The next oldest geomorphic unit is loosely termed "Subrecent." The dating of subrecent soils is difficult since no datable materials were recovered. However, judging from relative soil development, this unit can be placed between 500 and less than 7,000 years in age. It is found mainly north and east of the mound, as well as in a band to the south. The oldest surface is late Pleistocene in age and was deposited by the river Ravi when rapid glacial melting and erosion of foothill soils was taking place. Its most noticeable feature is the presence of large and dense calcite nodules (*kankar*) which have formed over time by the downward movement of carbonates. The radiocarbon age of the single sample of inner portions of these calcite nodules so far tested (7080±120 BP—Beta 21520) indicates that the soil reflects environmental conditions which existed prior to Harappan occupation.

These pedogenic carbonate nodules in soil at Harappa were recognized as a potential tool for interpreting environmental conditions prior to human occupation which began some 5,000 years ago. Carbon isotopes in pedogenic carbonate have the potential to be used to identify the vegetation type and density that existed during calcite formation. The basic conclusions of the lab tests are that the carbon isotope ratios of pedogenic carbonate in inner portions of nodules forming at Harappa reflect an arid climate with a very low soil respiration rate and sparsely vegetated conditions in early Holocene times. Whether the past pedogenic environment suggested by this data differs significantly from present natural conditions is not known with certainty and indicates a need for further investigation.

C. *Conservation and Site/Museum Development*

1. Personnel

The conservation laboratory was under the supervision of Donna Strahan who assisted in its original designing and outfitting. She was assisted this season by Harriet (Rae) Beaubien of the Philadelphia Museum of Art and Toseef-ul-Hassan of the Archaeology Conservation Laboratory, Lahore. Wassem Ahmed, Senior Chemist at the Lahore Museum, assisted in the lab for one month.

2. Conservation and Restoration of Excavated Materials

Because of the extreme salt problem at the site, desalinization was again a primary concern. The procedure was essentially that established during the second season, namely the soaking of the artifacts in distilled water for five to ten days or until the salt content was reduced to around 100 parts per million at which point they are deemed safe for storage.

As in the previous year, consolidation of friable terra-cotta objects was achieved with the application of 5% Acryloid B-72 in acetone after the object had air dried. Experiments are ongoing to improve the consolidation techniques. Reconstruction of vessels was

achieved through the use of the adhesive consisting of 50% B-72 in acetone. Losses or cracks were sealed with Acryloid B-72 and filled with plaster of Paris.

A variety of other materials were treated in the laboratory. For example, some of the copper alloy objects contained thread/string pseudomorphs on their surfaces. Mechanical removal of surface dirt was the only treatment performed on these objects. They were stored in air-tight containers with dry silica gel.

A silicone rubber mold was made of the only complete inscribed seal found this season. Baked Fimo molding clay impressions were made of all sealings and inscribed sherds. Assistance was given to the physical anthropologists in consolidating and reconstructing excavated cemetery bones by filling gaps with plaster.

The conservators assisted the museum curator in treating some of the delicate materials on display that required cleaning or repairing. Most in need of attention was the human burial display from the 1966 excavations in Cemetery R37. The intense summer heat had deteriorated the underlying materials supporting the skeleton, and some damage to the bones had resulted. Kennedy and Lovell, working with the conservators, removed the skeleton, replaced the cloth base, cleaned and repaired bones where necessary, and reinstalled the display.

3. Assistance to Site Curator

Two new displays were installed in the museum. The elaborate and unique headdress of microbeads discovered in a female burial during the 1987 season was displayed in a special dust-proof case in the jewelry section of the museum. Special authorization had previously been obtained to export the headdress for microexcavation and conservation by Donna Strahan at the Conservation Analytical Laboratory of the Smithsonian Institution, Washington, DC.

A representative burial from the current excavations was installed in the museum opposite the 1966 burial display. The burial was reconstructed inside a glass case, with a collection of funerary pottery and a complete extended burial laid out in a rough hewn wooden coffin. This represents one of several arrangements of pottery and coffins noted in the excavations. Such new displays with bilingual explanatory labels help visitors understand more about the ancient Harappans and also why the new excavations are being conducted.

D. *Training Program*

1. Pakistani Graduate Students

For the third year, Dr. Javed Husain brought graduate students from the University of Karachi for training. Also, for the second year, four students from Shah Abdul Latif University (Khairpur, Sindh) participated in the program. Rose Drees, of the University of Wisconsin, Madison, served as coordinator for the training program.

2. Conservation and Museum Personnel

For the second year, Toseef-ul-Hassan of the Department of Archaeology's Conservation Laboratory, worked with the Project's conservators in the Harappa field lab. Participating in all aspects of the work, desalinization, cleaning, repairing and restoring of artifacts, he has received practical training and experience in the basic techniques required in a modern field laboratory.

Two officers from Lahore Museum also participated in the laboratory and field training program. Waseem Ahmed working in the laboratory for one month, and Shahbaz Khan worked with J.M. Kenoyer on Mound E excavations as well as on various conservation projects.

Fourth Season: January—March, 1989

Objectives for the Fourth Season

A. *Excavations and Analyses of Scientific Samples*
1. Mound E
   a. Natural Soil
   b. Early Harappan Levels
   c. Harappan Levels
2. Mound AB
3. Collection of Samples for Analyses and Dating
   a. Pottery
   b. Figurines
   c. Copper Artifacts
   d. Stoneware Bangles
   e. Faience
   f. Ground and Chipped Stone Tools
   g. Bead Manufacture
   h. Carbon Samples for Dating

B. *Palaeoenvironmental Studies*
1. Palaeozoological Studies
2. Palaeobotanical Studies

C. *Conservation*

D. *Training Program*
1. Pakistani Graduate Students
2. Conservation and Museum Personnel

Description of Work Accomplished

A. *Excavations and Analyses of Scientific Samples*

1. Mound E

a. Natural Soil

The natural soil on which the earliest settlement was situated consists of a yellowish-brown silty sand that appears to represent river deposits, presumably of the ancient river Ravi. The height of the natural soil on which the settlement was established is 162.60 AMSL. This is 1.6 meters higher than the traces of the natural soil that were found in excavations between Mound E and Mound AB as well as to the south in the cemetery and in test pits west of Mound AB (300 meters in both direction). Although this elevation may result from the removal of natural sediments in the surrounding areas by human activity or later erosion, it is also possible that it represents a higher elevation on the ancient plain that was considered optimal for establishing the early settlement. Sedimentological studies done by Elise Pendall have also concluded that the site was situated on an elevated natural surface.

b. Early Harappan Levels

We have decided to use the term Early Harappan in a very general sense. At this time we do not know precisely how the culture and technology of these earlier inhabitants of Harappa contributed to, or resulted in, the later fully urban society of the Harappan phase. It was undoubtedly a very complex process of transition with some continuities and many discontinuities. Only after the final analysis of the artifacts and architecture will we be able to define more clearly what is meant by Early Harappan, Harappan, and Late Harappan.

The earliest cultural levels of the site can be attributed to the Early Harappan phase as defined by Mughal (1970, 1974). This interpretation is based on the preliminary observations of ceramics that are identical to examples reported from the Early Harappan levels at Kot Diji (Khan 1965), Jalilpur (Mughal 1972, 1974), and Rehman Dheri (Durrani 1988). In addition to ceramics, we have found grey fired bangles, stone blades made from a dark grayish chert, a stone celt, stone beads, and human figurines of a type that is not found in the following "mature" Harappan phase (Figure 13.32). Certain categories of artifacts found in these Early levels do, however, continue into the later "mature" Harappan phase. These artifacts include specific ceramic types, figurines, triangular terra-cotta cakes, terra-cotta toys and red fired bangles. The detailed study of these artifacts will hopefully clarify some of the questions about change and continuity between the Early and the "mature" Harappan phases.

We have located primary occupation levels of the Early Harappan phase all along the northwestern edge of Mound E, and in the section we have mapped Early Harappan deposits that form a mound that is 2.5 to 3 meters high at its exposed western edge (Figures 13.33, 13.34, and 13.35). The types of deposits include hearths, accumulations of domestic debris, and traces of mud-brick walls. One wall, associated with a small kiln, is made from small mud-bricks (7 × 12 × 34 cm), while another larger wall at the northwestern perimeter of the site is made of bricks that are much larger (10 × 20 × 40). These walls are only partially exposed, but the orientation is northwest to southwest at an angle of approximately 10° west of true north.

One exciting discovery in the Early Harappan levels is a small circular kiln, 50 × 60 cm in diameter and approximately 40 cm high. This kiln has a unique firing structure made by placing the upper half of a large pot in the center of the kiln. This vessel and another large pot found inside the kiln are both Early Harappan vessel types. The fuel appears to have been placed on the outside of the broken pot as well as on the inside. However, the interior of the pot is vitrified and reduced while the exterior is oxidized. This suggests that the objects being fired may have been placed inside the pot for a high temperature reduction that would have resulted in dark grey or black color.

In our excavations, we have discovered at least five and possibly six different walls that are made of large mud-bricks (10 × 20 × 40 cm) and are associated with Early Harappan ceramics. Two of these walls are quite eroded and are sealed by Early Harappan deposits, while the other three or four were built on the natural soil or by cutting foundation trenches into Early Harappan deposits.

The most complete wall (Feature #[164]) extends north-south for over 15 meters (Figure 13.33). It is two meters wide and stands approximately two meters high (Figure 13.35). A possible corner of this wall has been identified but the eastern extension has been completely obliterated by later construction. A second wall (Feature #[235]) was built after this wall #[164]. It is 2.5 meters wide and has a well defined corner and eastern extension that continues for about four meters. Both of these walls (#[164] and #[235]) are made from mud-bricks that have several distinct colors of clay. These different colors represent different source areas for the clay, and one can hypothesize that the bricks were prepared in different areas around Harappa and brought to the site for construction of these massive walls. The precise function of the walls is not clear, but since the exterior face is invariably eroded and the interior face is not eroded, they may have functioned as retaining or revetment walls. They could have served to protect the edge of the mound from floods or erosion as well as presenting a formidable elevation to discourage unwanted intruders.

These walls represent a fairly massive scale of architecture, and it is not likely that this scale of construction would have been undertaken on an individual basis; rather it may reflect some form of Early

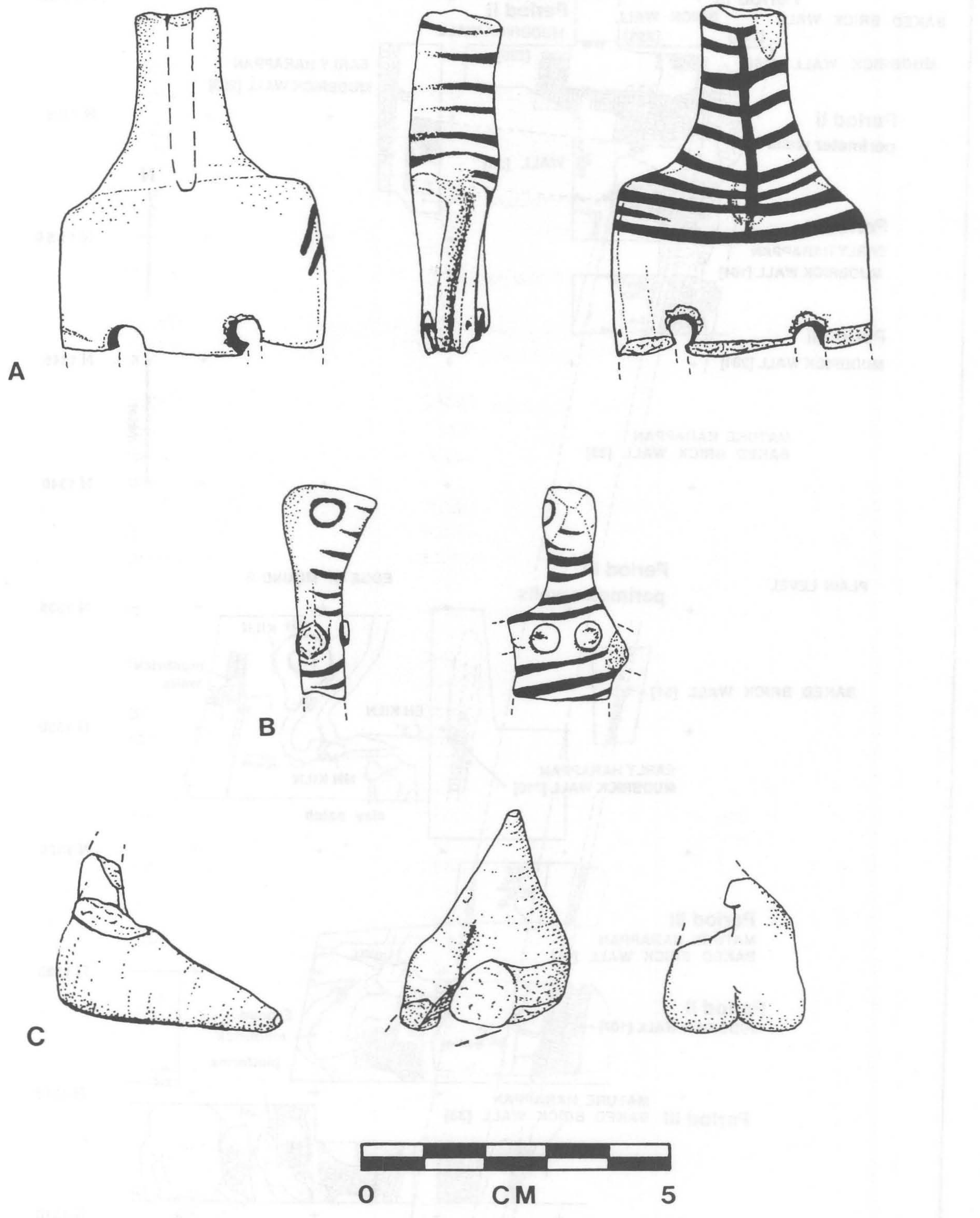

Figure 13.32: Harappa 1988: Early Harappan phase figurines from excavations in northwestern corner of Mound E.

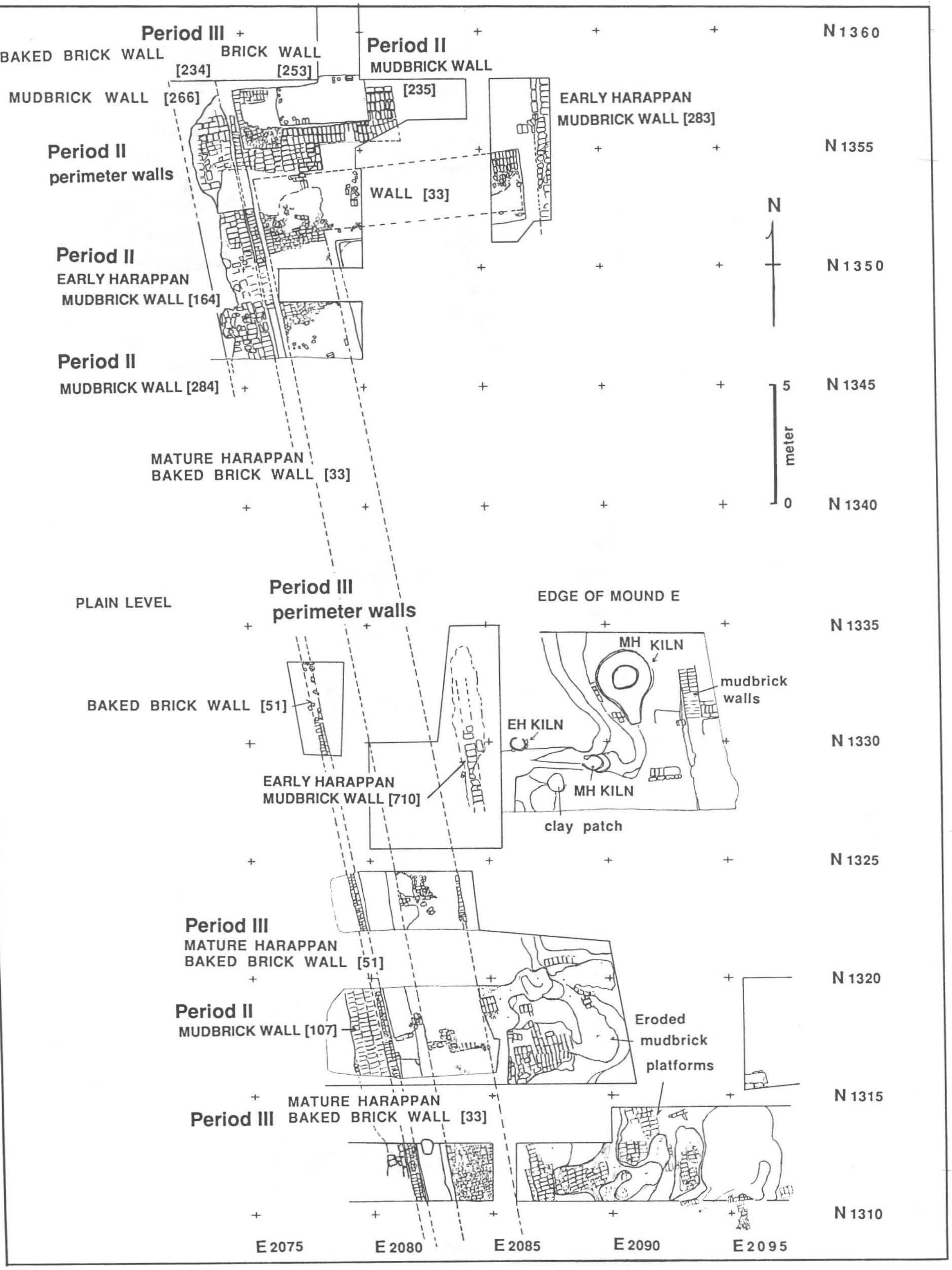

Figure 13.33: Harappa 1989: Mound E, northwestern corner: plan of Early Harappan and Harappan phase architecture.

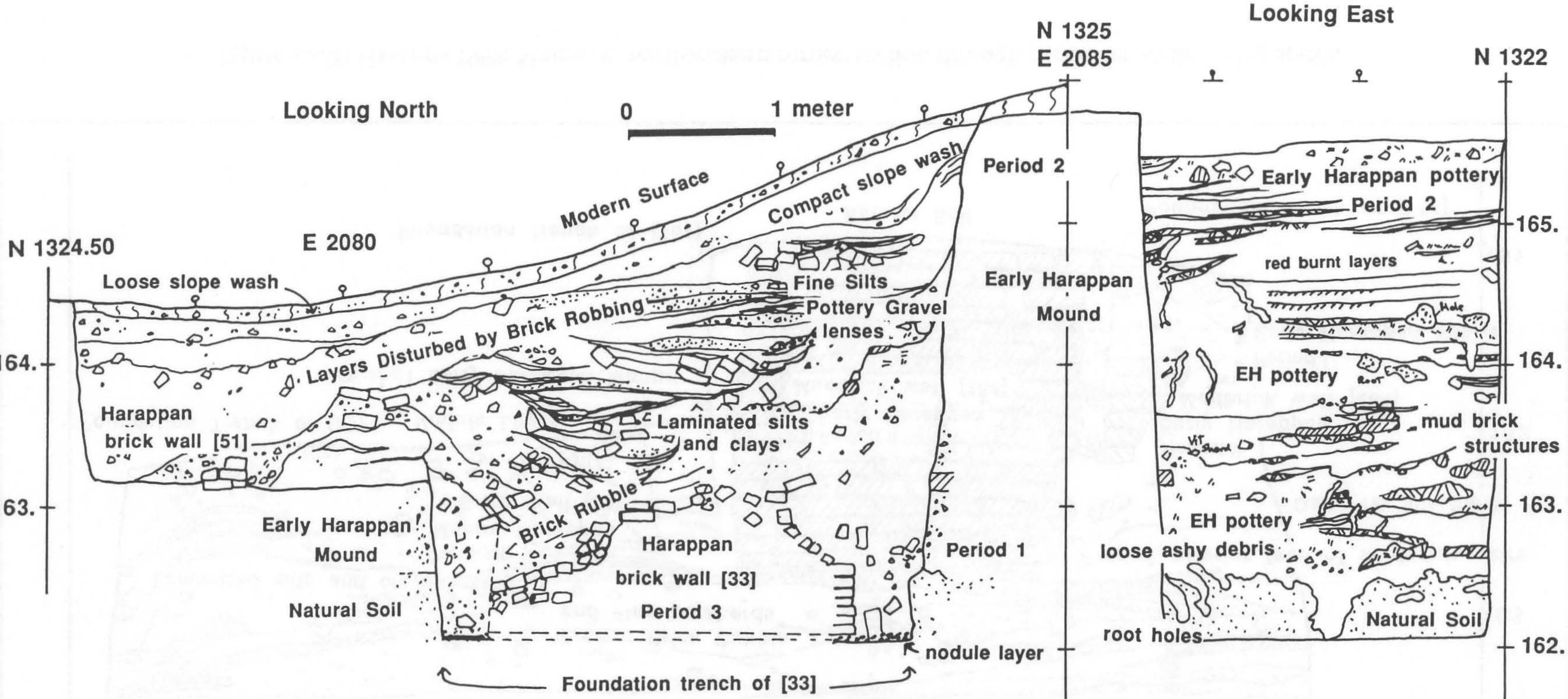

Figure 13.34: Harappa 1989: Mound E, northwestern corner: section through Harappan phase deposits and Early Harappan mound, facing north and east.

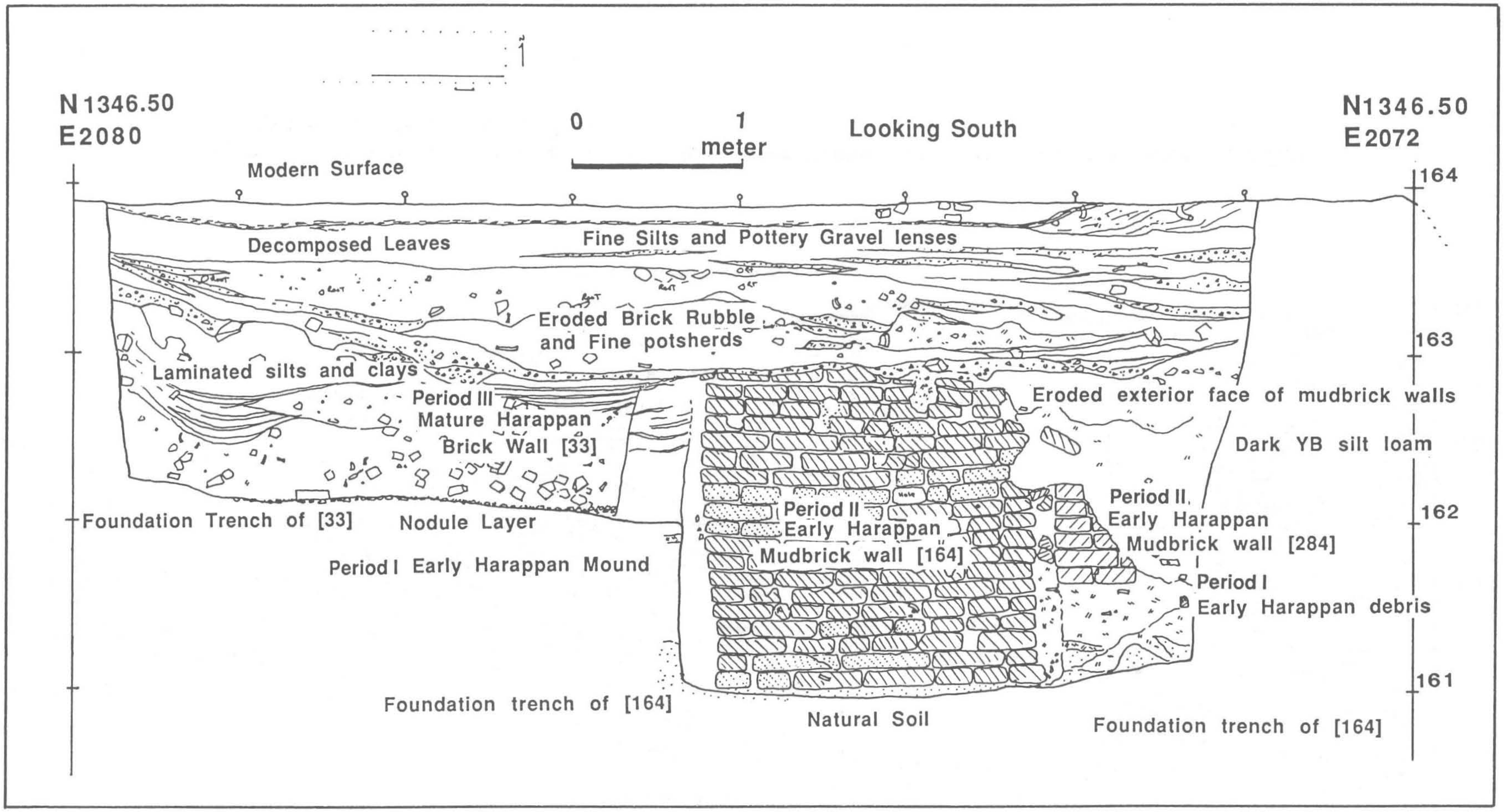

Figure 13.35: Harappa 1989: Mound E, northwestern corner: section through perimeter walls, facing south.

Harappan social organization with the ability to mobilize and control the production of large quantities of mud-bricks as well as the labor involved in the construction of the walls.

c. Harappan Levels

Excavations on Mound E uncovered a relatively thin wall of baked brick (Feature #[51]) that is approximately 45 to 50 cm wide and has now been traced for over 35 meters (Figure 13.33). It has been rebuilt at least three times and the exterior edge is heavily eroded, while the interior face is still intact. This pattern suggests that it may have functioned as a retaining rather than a free-standing wall. Evidently it did not do its job well, because the Harappans later built a larger and more massive structure, wall (Feature) #[33]. They did this by cutting through the thin wall and digging a large foundation trench that essentially shaved off the edge of the Early Harappan and "mature" Harappan mound to a height of 3.5 to 4 meters (Figure 13.34). The foundation trench cut through the Early Harappan layers and down into natural soil. Before building the wall the architects laid a thin layer of overfired nodules along the entire length of the trench, and it is interesting to note that the level of the bottom of the wall has only a 2 cm variation along its entire exposed length (45 meters).

The brick sizes in wall #[33] are generally 7.5 × 16 × 34 cm which is the same size as the mud-bricks used during the Harappan phase. The wall is 2.5 meters wide, with brick bonding the same as in the earlier mud-brick platforms. It is aligned in the same orientation as the Early Harappan mud-brick walls (10° west of true north) and even has the same corner angle (83°). The eastern extension is nine meters long and ends abruptly with no evidence for a gateway or entrance. In one area we have been able to reconstruct a height of 3 meters, but the actual wall is preserved to only 1.3 meters. Although the exterior face is battered at a very small angle of 5°, the angle of the foundation trench on the interior edge of the wall suggests that it was constructed with a more pronounced batter and rested against the face of the mound. On the basis of the present excavations there is no indication that this wall was free standing. Therefore it too seems to have functioned as a revetment or retaining wall, indeed a very massive one.

Just east of the Early Harappan kiln, described above, a small kiln of the Harappan phase was discovered (Figure 13.33). The small Harappan kiln is structurally different from the Early Harappan kiln in that it is tear-drop shaped and has a definite opening to the west for air and possibly fuel (80 × 75 × 30 cm deep). A preliminary interpretation is that this kiln was used as a pit-kiln that was plastered to form a domed covering, presumably with vent holes. After each firing the structure was broken open and then rebuilt. One interesting feature in the mouth of the kiln is the concentration of numerous low fired triangular terra-cotta cakes and *mushtikas* (potato shaped clay lumps with finger impressions). Their presence at the mouth of the kiln could be explained as a method for allowing air into the kiln and at the same time effectively sealing in the heat. Traditional potters in Pakistan place old pots or stones at the mouth of similar kilns for this particular purpose.

The small Harappan kiln is covered by more strata containing kiln wasters and ash, indicating further ceramic production in this area of the site. Again this hypothesis is confirmed by the presence of the slightly later, but much larger kiln just to the north that was partially excavated during the 1988 season (Figure 13.28). This larger kiln measures almost 2 meters east-west and 3 meters north-south. It is tear-drop shaped with an extended opening to the south for air or fuel. The precise construction and operation of this kiln is under study.

Large quantities of vitrified pottery were found around the kiln and in eroded strata on the slopes. In layers associated with its use was found a chuck-mould for making the base of large storage jars and a wide range of "mature" Harappan pottery that may have been produced in the kiln. These types include dish-on-stand, medium-to-large painted pots and jars, perforated vessels, and medium-to-large plain wares, but no evidence for the production of pointed base goblets or smaller plain wares. In these levels we also found fragments of hematite used for making pigments, bone spatulas and worn stone blades for trimming, and patches of fine clay that may represent the areas where potters were mixing or wedging the clay. [*See also Chapter 6 in this volume.*]

2. Mound AB

Although excavations were resumed inside the Harappan well (Figure 13.21), the operation was halted for safety reasons after clearing only 75 cm below the previous season's levels. The cracks and bulging in the lower exposed wall were more pronounced than they were in the third season, so a substantial concrete cap was put on top to preserve the well as it is and for possible future investigations.

During the previous season, large quantities of Late Harappan (Cemetery H) sherds and mud-bricks that are not of the standard Harappan phase size were observed along the crest of the western side of the gully. This evidence suggested that that some Late Harappan architecture had escaped the 19th century brick robbers.

One north-south trench was opened along the crest and three smaller east-west trenches were extended over the crest of the gully. The results of these excavations show that most of the deposits on this part of Mound AB are disturbed debris layers resulting from brick robbers' activities and natural erosion. In the east-west trenches, the level of Harappan structures was reached, which included baked brick walls, possible drain fragments, and a hearth. There was no evidence for habitation levels of the Late Harappan phase, and it is assumed that this area of the site has been completely destroyed by historical period brick robbing and natural erosion. Several historical period burials were encountered in the north-south trench. These burials were left *in situ*, re-covered, and excavation was not continued in these areas.

Two test trenches were excavated on the plain level between Mound AB and Mound E. In both trenches natural soil was reached at approximately 161.07 meters AMSL. In the upper levels of these trenches historical period structures using Harappan phase bricks were identified. Below these late structures the strata were comprised of pits and debris dumps filled with Late Harappan or Harappan pottery. In one level it appears that there was a paving of crushed brick and pottery that may have been a roadway of the Harappan phase. The lowest level of silty wash above the natural grey soil contained small fragments of Early Harappan pottery and grey bangle fragments.

3. Collection of Samples for Analysis and Dating

a. Pottery

Several members of the staff worked with the pottery this season: Dales, assisted by graduate student Paul Christy Jenkins focused on the typological classification system; Rita Wright and J. Mark Kenoyer were concerned with the technological aspects of the raw materials and the manufacturing and firing procedures; and Rose Drees studied the Cemetery H pottery. Archaeometric analysis of the pottery is being conducted by Rita Wright in order to define continuities and/or discontinuities between the Early Harappan and Harappan phases. Her studies involve characterization of the raw materials used in the preparation of the clays, the slips and paints, and the temperatures used to fire the ceramics. Complemen-tary studies involving petrographic analyses of the ceramics are being conducted at the University of Wisconsin, Madison.

The initial documentation of the Harappa pottery was based on the classification of the Mohenjo-daro pottery published by Dales and Kenoyer (1986) (Figure 13.36). As we anticipated, differences immediately became apparent between the pottery of the two sites, and the classification system is being modified to accommodate them.

The revised Harappa classification system is superior to that used at Mohenjo-daro because it is based almost exclusively on complete vessels rather than the incomplete forms and sherds available for the Mohenjo-daro study. In addition to the newly excavated vessels, there is an enormous reserve collection of complete vessels in the museum storeroom from earlier excavations. Dales and Jenkins are developing a handbook of basic pottery forms and their variations. The technical and artistic characteristics of each form category will be added. With this handbook it will be possible, in most instances, to identify pottery categories from sherds so that more accurate distribution studies can be made of specific pottery types. [*See also Chapter 5 in this volume.*]

Rose Drees began cataloging the newly collected Late Harappan, Cemetery H pottery. She obtained permission to study some of the complete vessels from Vats's 1927-28 cemetery excavations that are stored in the site museum. Vats published only a limited number of the complete vessels and even for those, the drawings and photographs are so small as to be almost useless (Vats 1940).

b. Figurines

More than 550 non-anthropoid figurines were collected during the fourth season. In conjunction with the expedition's zooarchaeologist, we are developing a multi-variant coding system for these figurines. The correlation tests are not complete but the preliminary study suggests the following breakdown:

Animal Type	#	%
Quadruped Mammals*	133	24.5
Horned Quadrupeds*	88	16.2
Cattle	164	30.3
Water Buffalo	58	10.7
Rhinoceros	34	6.3
Sheep/Goat	15	2.8
Other**	50	9.2

*Not more specifically identified

**Dog, Cat, Primate, Bird, Turtle, Elephant, Unicorn

These figures suggest that cattle outnumber sheep/goat by 10 to 1; cattle outnumber water buffalo by 3 to 1; and cattle outnumber rhinos 5 to 1. Of the 164 identifiable cattle, *Bos indicus* outnumber other types of cattle by 2 to 1.

After refining the identifications of these figurines, comparisons will be made with the ratios of species known at Harappa from the actual faunal remains to see what, if any, meaningful relationships there are

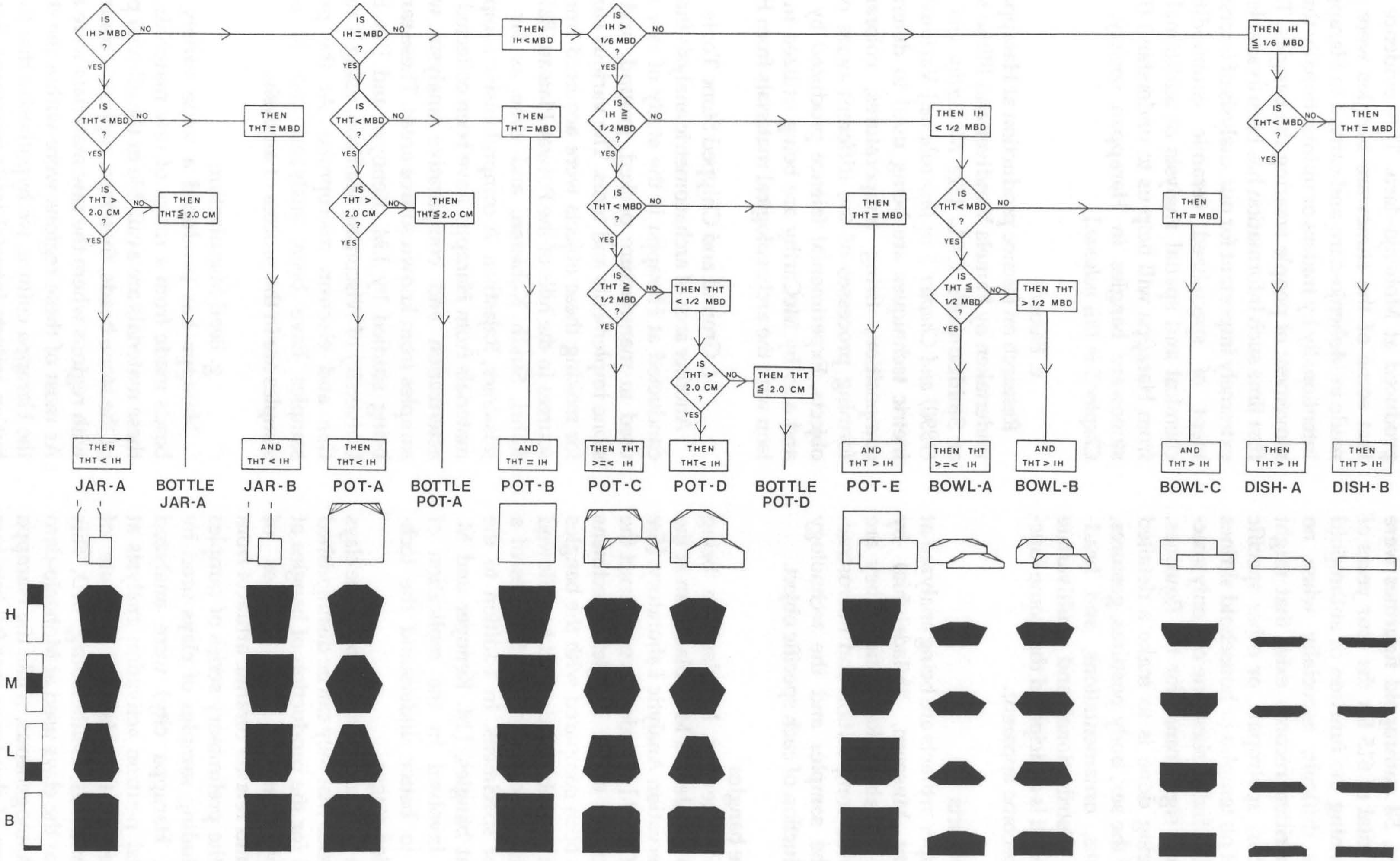

Figure 13.36: Flow chart of vessel forms created for classification of Mohenjo-daro ceramics (Dales and Kenoyer 1986).

between figurines and animals actually exploited by the Harappans.

During this season, 58 anthropoid figurines were recorded, making a total of 615 for the four years of excavations. Determining the function of anthropoid figurines is always difficult, especially when no contemporaneous, written records exist that might give clues to religious, apotropaic, or other specific functions. Given that no temples or household shrines have been identified at Indus sites, one can only speculate as to a religious significance for the figurines. What can and is being done is to make a detailed attribute analysis of the sex, body postures, gestures, facial representations, ornamentations, and head-dresses. When the distributional and multivariate studies are completed, it is anticipated that some functional patterns will become apparent.

c. Copper artifacts

Samples from copper artifacts are being analyzed at MASCA (University Museum, Philadelphia) by Vincent Pigott and Elizabeth Reistroffer. They are studying the elemental composition and microstructural features of the samples and the technology involved in the production of each specific object.

d. Stoneware bangles

The remarkable stoneware bangles are being studied by Massimo Vidale and M. J. Blackman at the Smithsonian's Conservation Analytic Laboratory. [*See Blackman and Vidale (1992).*] In order to reconstruct the manufacturing processes of the bangles, specimens from Harappa have been compared with the bangles of Mohenjo-daro. This combined data set has allowed us to record the micro-morphological features of a substantial group of specimens. In addition to the study of the ancient bangles, J.M. Kenoyer and M. Vidale have been involved in the replication of stoneware bangles to better understand the technology and production stages.

The analysis of the chemical composition of the clays used at Harappa reveals that they can be distinguished from the clays used for the production of bangles at Mohenjo-daro. Approximately 100 samples of stoneware bangles and related ceramic artifacts from Mohenjo-daro and the preliminary series of samples from Harappa (including samples of clays used by modern potters at Harappa city) were analyzed through instrumental neutron activation analysis at the reactor facilities of the National Institute of Technology and Standards, Gaithersburg, MD. This analysis revealed that the clays used at Mohenjo-daro appear to be fairly homogeneous, while the Harappa samples show a range of clay types that fall into two major categories: bangles made from clay that is chemically similar to clays found in the region today, and bangles that are chemically identical to the bangles produced at Mohenjo-daro. This evidence suggests that some of the stoneware bangles were probably made in Mohenjo-daro and carried to Harappa, either intentionally by traders or unintentionally through the movement of people wearing the bangles. This is the first time such information has been available, and it is extremely important for our analysis of intersite movement of specialized ceramic commodities. The chemical and spatial analysis of additional samples from Harappa will help us to understand the role of stoneware bangles in Harappan society. [*See also Chapter 5 in this volume.*]

e. Faience

Research on faience production at Harappa is being undertaken by Pamela Vandiver and Blithe McCarthy at Smithsonian's CAL. [*See McCarthy and Vandiver (1990) and Chapter 5 in this volume.*] Various archaeometric techniques are being used to determine the composition, firing temperatures, colorants, and forming processes of the different types of faience objects. Experimental faience produced by Kenoyer and also by McCarthy are being utilized in comparison with the archaeological materials from Harappa.

f. Ground and Chipped Stone Tools

Another area of archaeometric analysis that is being conducted at Harappa is the study of raw materials used to manufacture pecked, ground, and chipped stone implements and tools. The various stones used for making these objects were acquired from distant sources in the hills of the Potwar Plateau, Baluchistan, Rohri, Sindh Kohistan, and even as far away as Jaisalmer, Rajasthan. A comprehensive sample of raw materials from Harappa have been collected for characterization and comparative analysis with rock samples from known source areas. These samples are being studied by J.M. Kenoyer and Jim Burton at University of Wisconsin, Madison, using X-ray defraction and electron microprobe. At the present 10 samples have been analyzed and 30 additional samples are in the process of analysis.

g. Bead Manufacture

Harappa has produced a wide variety of stone beads made from a range of raw materials. None of these materials are available in the alluvial plains. All of the stone beads, therefore, represent trade contacts with regions where the raw materials were available. As most of these regions were within the domain of the Harappa culture, we hypothesize that their distribution reflects internal trade networks. Some of the raw materials—for example, carnelian, banded agate,

and amazonite—occur in Gujurat, India. Lapis lazuli was probably obtained from the Chagai Hills in Baluchistan or from the mines in Badakshan, Afghanistan. Various colors of steatite could have come from Baluchistan or from Rajasthan. Variegated jaspers and limestones could have been acquired in the Kohistan or Baluchistan region as well as from Rajasthan, Kathiawar, Kutch, or Saurashtra. The identification of specific source areas is being done through the collecting of modern samples of raw materials for comparative studies using petrographic characterization and trace element analysis.

Studies of bead manufacturing techniques are also being conducted by J.M. Kenoyer. Some of the raw materials are microcrystalline silicates and can be easily flaked, while other crystalline materials were fashioned by grooving and splitting, sawing, or simply grinding. One of the most important manufacturing stages is the drilling of the beads. Every excavated bead is being studied to determine the type of drilling technique used. Silicone impressions of the drill holes are made and these casts are being studied by Kenoyer and Jim Burton under the Scanning Electron Microscope at the University of Wisconsin, Madison.

h. Carbon Samples for Dating

This season we continued to collect carbon samples from primary context deposits ranging from the earliest to the latest levels of Mound E. To date, 20 samples have been submitted for dating. [*See Chapter 4 in this volume.*]

B. *Palaeoenvironmental Studies*

1. Palaeozoological Studies

It is clear from the analysis by Richard Meadow of the collection of animal bones excavated during the 1986 season on Mound AB, that wild animals including deer, blackbuck and gazelle, fish, turtles, and birds were important to at least part of the population during the "mature" Harappan phase. This hypothesis requires confirmation from other parts of the site since the use of different animals for food may have varied through the ancient city according to what sections of the population had access to different animal resources.

With the discovery of extensive Early Harappan deposits at Mound E, we can also address the question whether the exploitation of animals changed during the transitional period that saw the development of the full urban period.

During the fourth season, all the previously excavated faunal materials were cleaned for analysis. A number of samples from Mound E were examined and documented and other materials from that area were selected for export to the Peabody Museum, Harvard University, for study.

There are often difficulties in differentiating some of the skeletal parts of water buffalo and cattle and of humped and non-humped cattle, as well as other forms of large bovines. As a result, Meadow and James Knight made a collection of bones of recently deceased animals from modern 'bone-pits' located outside of Harappa town. Specimens from 43 animals were collected and prepared by simmering in laundry detergent. These include bones of water buffalo, zebu cattle, horse, donkey, and mule. A complete collection of these modern specimens is stored at Harappa to assist future researchers who may wish to study faunal material from other archaeological sites in Pakistan.

2. Palaeobotanical Studies

The palaeobotanical materials collected this season, mainly by using flotation techniques, include a large percentage of carbonized seeds. Botanical samples were taken to the University of Wisconsin, Madison, for cleaning and identification by Heather Miller and Seetha Reddy. Steve Weber of the University of Pennsylvania has also assisted in the identifications and analyses. These and future collections will provide the first systematically recovered plant assemblage from a large, urban period Harappan site.

A wide range of of plants has been identified from samples collected on Mound E, spanning the Early Harappan and Harappan phases. The remains examined to date are primarily winter grain crops of wheat and barley, together with a fine collection of legumes. Also, there are remains of wild seeds, including many "weedy" types, and seeds of various small, wild grasses. In addition to the carbonized seeds, we have collected numerous impressions of grasses and seeds that were found in the packed clay and silt floors of structures and in mud-bricks.

Carbonized wood samples, including those found around the kiln area, have been collected and sent to Stéphanie Thiébalt (Laboratoire de Paléobotanique, Montpellier, France) for identification.

C. *Conservation*

The field laboratory was supervised this season by Harriet Beaubien of the Smithsonian's Conservation Analytical Laboratory. She was assisted again by Toseef-ul Hasan of the Department of Archaeology's laboratory in Lahore Fort as well as by Barbara Dales and Dawn Morton.

Desalinizing, cleaning, and restoring excavated materials occupied most of the time of the conservation personnel. Also, the staff continued to work with the site curator in specific matters relating to conservation of museum artifacts.

D. *Training Program*

1. Pakistani Graduate Students

Eight graduate students from the University of the Punjab, Lahore, participated in a one month field training program.

2. Conservation and Museum Personnel

Toseef-ul-Hassan worked for the third time in the conservation laboratory. Tariq Masud, Lahore Museum, received training and practical experience in various aspects of field excavation and specialized training in matters relating to the conservation of artifacts.

Fifth Season: January—March, 1990

New Terminology

Through the analysis of the data collected from the 1986-1989 excavation seasons, we have decided to use a preliminary chronology consisting of five distinct periods specific for the site of Harappa. These periods consist of Period 1 (Early Harappan), Period 2 (Transitional), Period 3 ({"mature"} Harappan), Period 4 (Harappan/Late Harappan Transition) and Period 5 (Late Harappan/Cemetery H). We expect to use these Period numbers throughout subsequent preliminary reports.

Objectives for the Fifth Season

A. *Excavations*
   1. Northwestern Corner of Mound E
   2. Southern Slope of Mound E

B. *Analyses of Specific Categories of Artifacts*
   1. Pottery
   2. Figurines
   3. Inscriptions
   4. Miscellaneous

C. *Palaeoenvironmental Studies*
   1. Palaeozoological Studies
   2. Palaeobotanical Studies

D. *Conservation*

E. *Training Program*
   1. Pakistani Graduate Students
   2. Illustrators

Description of Work Accomplished

A. *Excavations*

1. Northwestern Corner of Mound E

In the fifth season, excavations at the northwestern corner of Mound E were expanded to obtain more information on the transition from the pre-urban to the full-urban periods (Figure 13.37). Three adjacent trenches were excavated, covering an area of approximately 15 × 15 meters. The Period 1 and 2 levels were accessible in an area of 10 × 2 meters along the edge of the mound. In this narrow area, we exposed habitation debris associated with mud-brick walls. Two different structures with sets of parallel east-west walls were mapped. The bricks of these Period 1 and 2 walls measure approximately 10 × 20 × 40 cm. While the Period 1 and 2 bricks are larger than Period 3 bricks, their dimensions are in the same ratio. Although the excavated area is limited, these walls indicate the presence of rooms or houses of the Early Harappan (Period 1 or 2) occupation that have the same cardinal orientation as subsequent Period 3 structures.

In addition, during the 1990 season, in a 5 × 5 meter area near the Period 1 exposures just described, we removed approximately three meters of Period 2 and 3 deposits. In future seasons, this excavation will facilitate horizontal exposures of Period 1 domestic structures. The transition layers in this area are dominated by ceramic production debris, hearths, and large quantities of carbonized grains and other plant remains.

The fact that all of the strata in the 5 × 5 meter excavation area are deposited horizontally suggests that during Periods 1 and 2 there was a substantial retaining wall at the edge of the slope or that the mound extended much farther to the west. Although evidence of a Period 1 and 2 wall has not been discovered, previous excavations at the edge of the mound have demonstrated that, during Period 3, a large retaining wall, two meters wide and over three meters high, was constructed at the edge of the mound. It is possible that during the preceding transitional period, in the position of the currently visible Period 3 retaining wall, there may have been an earlier mud-brick revetment wall or platform that has not survived.

Overall, the area appears to have been continually occupied without a major hiatus. Within this continuous sequence, however, change was observed in the composition of deposits (Figure 13.38). Superimposed on the thin, multiple horizontal deposits are thick, massive layers containing baked brick fragments and red brick dust. The introduction of baked brick architecture is one of the defining characteristics of Period 3. The alteration in deposition, however, may reflect a change in the range of activities conducted in the area. Further analysis of the artifacts collected from these well-stratified deposits will offer fresh clues to the evolution of Period 3, Harappan, culture from its Period 1 and 2, Early Harappan, roots.

2. Southern Slope of Mound E

During the 1990 season, six separate but closely related excavation areas were opened along a large

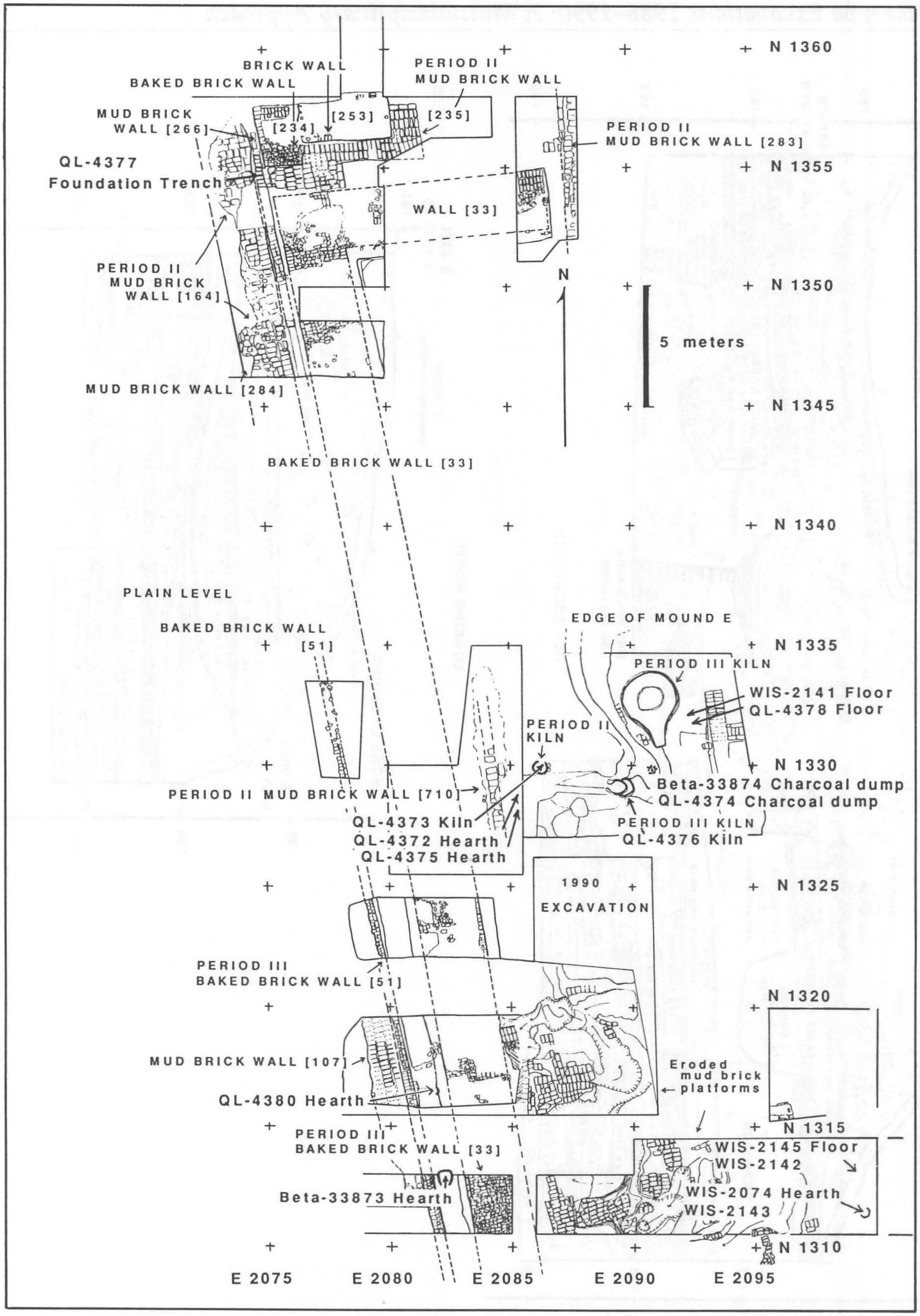

Figure 13.37: Harappa 1990: Mound E, northwestern corner: plan of Early Harappan and Harappan phase architecture.

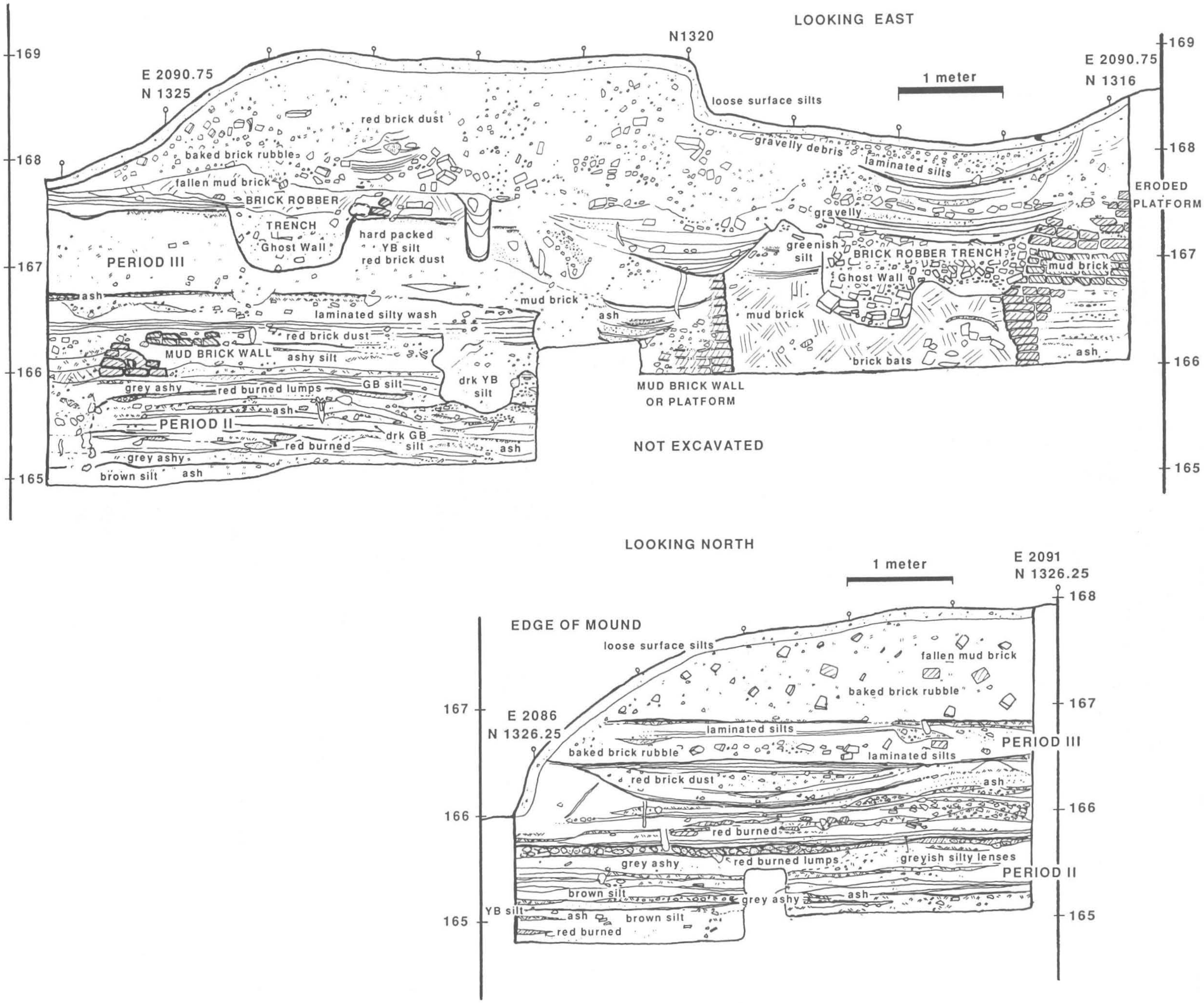

Figure 13.38: Harappa 1990: Mound E, northwestern corner: sections through Period 2 and Period 3 deposits, facing east and north.

north-south erosional gully on the southern slope of Mound E. For the purposes of this season's report, these operations, in order from north to south, are designated as Areas A to F (Figure 13.39).

The major feature that was found in Areas B, C, and D during the 1990 season is an impressive five meter wide street. This street is designated NS2355 because it lies along the East 2355 meter grid line. The street has been traced for some 30 meters from the southern edge toward the center of the mound.

To the south, in Area E, an east-west aligned baked brick drain is located across the projected southern axis of street NS2355. This structure may represent a drain crossing the path of the NS2355 street or may be associated with an intersecting east-west thoroughfare that is as yet unexposed.

In Area B, the maximum width of the street in Period 3 (Harappan) is approximately 5 meters. In Area C, a narrow brick paving and drain may represent an encroachment into the street that restricted the flow of traffic during the latest phase of Period 3. The street surface in this latest phase is pitted with pot holes and with what appear to be north-south oriented cart tracks filled with refuse (Figure 13.40).

The levels of street NS2355 were excavated to natural soil in Areas B and C with exposures of 2 × 3 meters and 2 × 5 meters, respectively. At the lowest levels of the street it was again possible to define what appear to be cart tracks (Figure 13.41). In these street levels Early Harappan sherds were recovered. The north-south alignment of these cart tracks associated with Period 1 sherds indicates that the street orientation remained constant from the earliest levels through to the final occupation of this area in Period 3.

Area A (Figures 13.42 and 13.43), a 10 × 5 meter unit, is located farthest inside the mound and is situated to the east of the alignment of street NS2355. Our excavations exposed Period 3 habitations consisting of baked brick walls constructed on top of massive mud-brick foundation platforms. Most of the latest Period 3 baked brick walls had been robbed, but drains and the interior fill of the rooms were preserved. The lowest exposed levels revealed a room or courtyard with numerous superimposed hearths. A small drain (Feature #[68]) exited the room and flowed south to join a larger east-west drain (Feature #[46]) which may be associated with an east-west alley-way or small street.

Ceramics collected from the lowest excavation levels in Area A are associated to Period 3, but there are some sherds with stylistic similarities to Period 1 and/or Period 2 pottery. Much of the refuse in the pair of successive drains consists of pottery, and changes in specific Period 3 ceramic forms are recognizable.

In Area B, a 5 × 10 meter trench was excavated across the gully to determine the width of the street and to expose habitation structures on either side. On the western edge of the street there is evidence for large structures that had been robbed of their baked bricks presumably during the mid-19th century. A north-south wall was defined along the western edge of the street from the outlines of the robber trench. Similarly to the east, a second pillaged wall demarcated the eastern edge of the street. Traces of baked brick walls, mud-brick pavings, and an unusual hearth were uncovered on the east side of the street. These domestic features are very similar to better preserved structures to the south in Area C. Two faience tokens, one flat-rectangular and one triangular in section, were recovered from within the habitation deposits of Area B (Figure 13.44h-i). A small trench, 2 X 3 meters in area, was excavated to natural soil along the eastern edge of the street. The lowest street level consisted of natural soil churned with a darker brown silty loam.

In Area C, south down the slope of the mound from Area B, an area of approximately 10 × 10 meters was excavated to obtain a stratigraphic sequence down to natural soil and to horizontally expose the Period 3 structures that had been identified through the surface surveys.

At the lowest levels of Area C, considerable deposits containing Period 1 and 2 pottery, hearths, and mud-brick structures were exposed (Figure 13.45). Two phases of mud-brick construction were identified. The earliest structure is a north-south wall associated with Period 1 and 2 pottery and resting on natural soil, while the later one is a fallen wall seen in section. The brick sizes are approximately 6 × 16 × 28 cm. Above these structures are approximately 1.5 meters of laminated ash and silt deposits with Period 1 and 2 pottery. Several superimposed hearths were excavated that contained datable carbon and concentrations of charred grain. This pattern of superimposed hearths suggests that domestic structures were located adjacent to the north-south street and that this pattern of habitation was continued into Period 3. Preliminary investigation of the ceramics and the associated artifacts suggest that there is no major hiatus or cultural break between the Period 1 and 2 and Period 3 levels in this area of Mound E.

Lying directly above the Period 1 and 2 material are deposits with Period 3 pottery and a mud-brick structure. Only a portion of the mud-brick structure was exposed, but it appears to consist of two rooms containing domestic debris. These mud-brick walls were eroded and sealed by a deposit of refuse that included almost complete carcasses of cattle and bones of sheep/goat and dog. The presence of this deposit

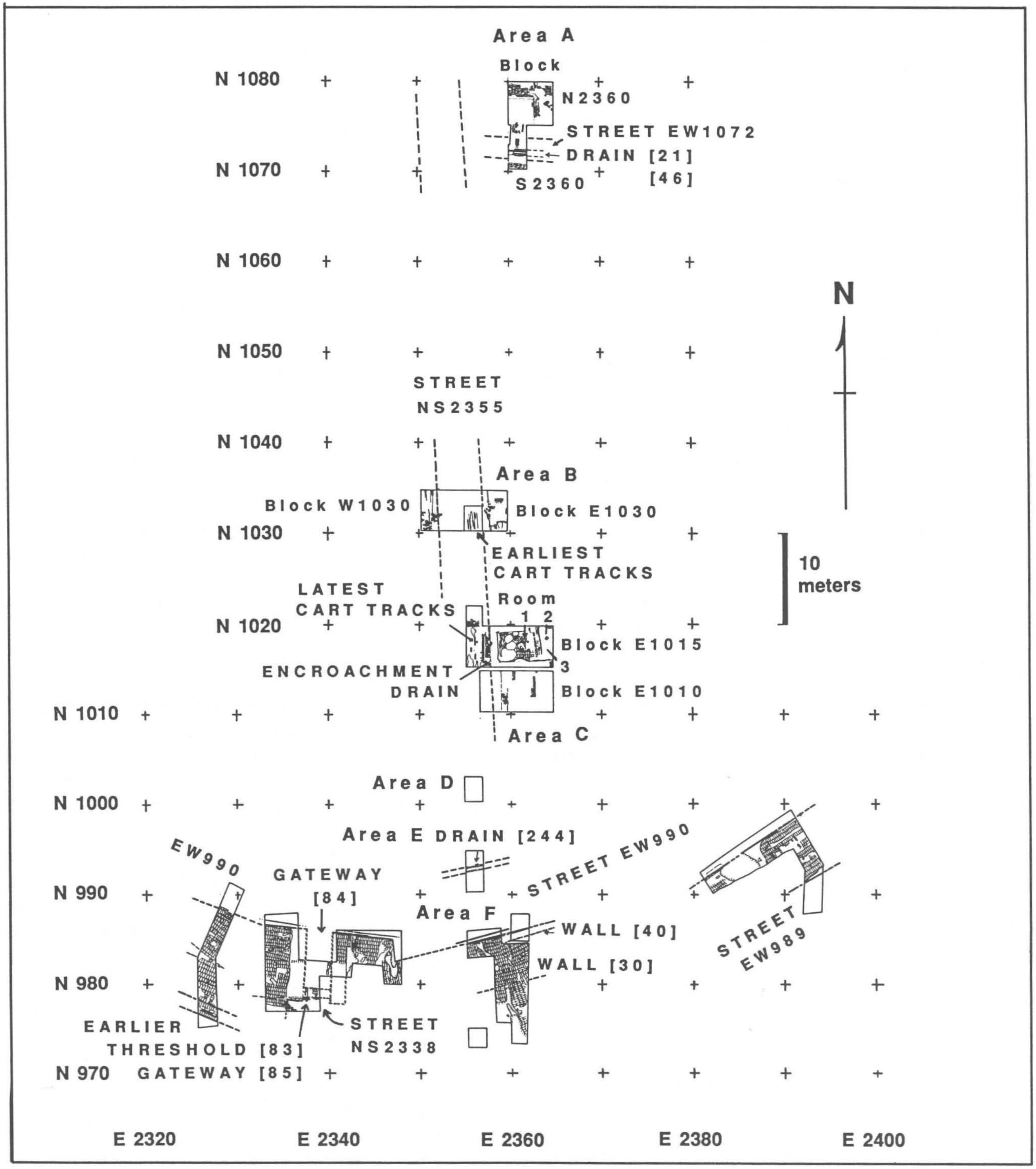

Figure 13.39: Harappa 1990: Mound E, southern slope: general plan of area excavated.

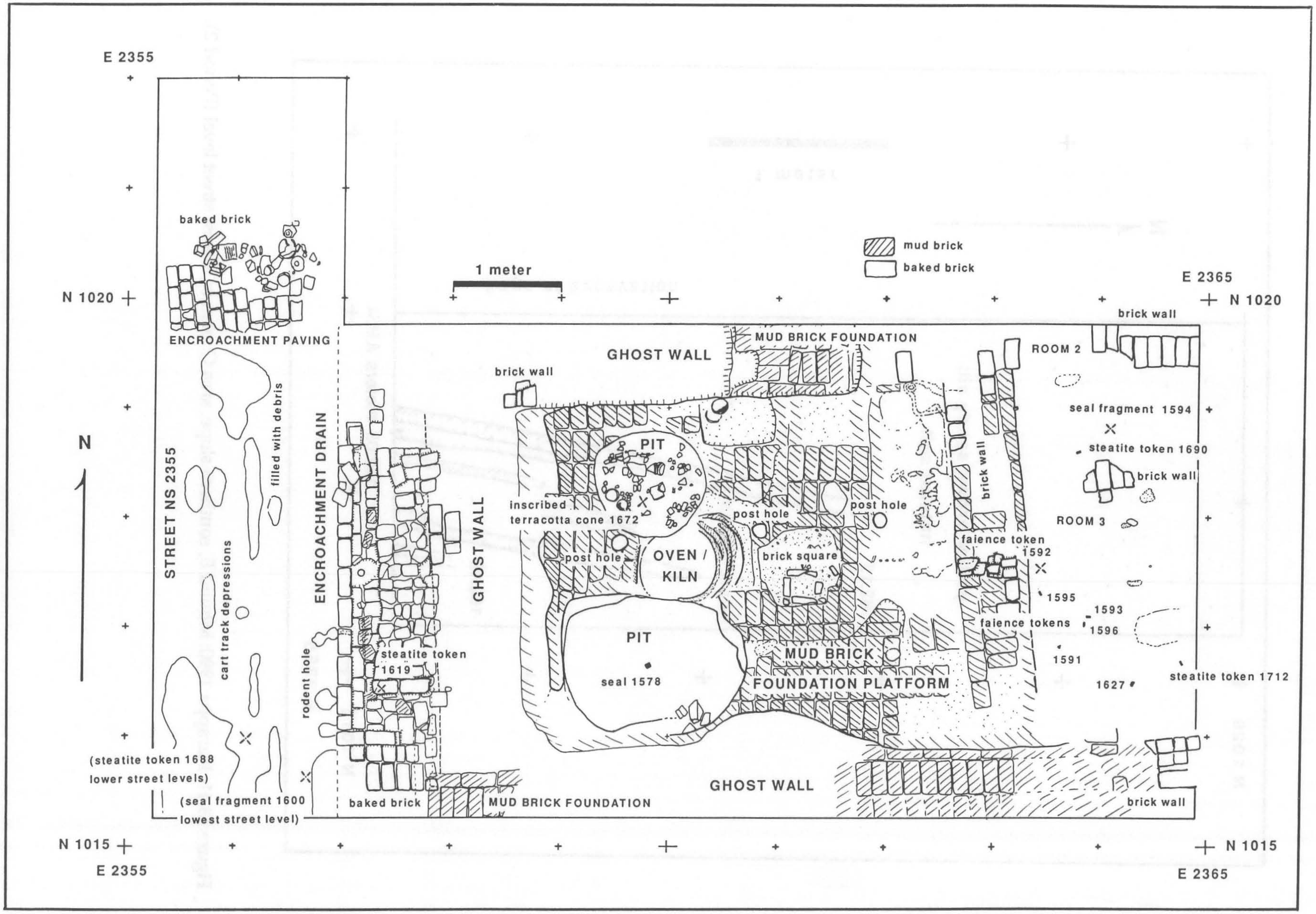

Figure 13.40: Harappa 1990: Mound E, southern slope, area C: plan view of Harappan phase (Period 3) house structure and upper street levels.

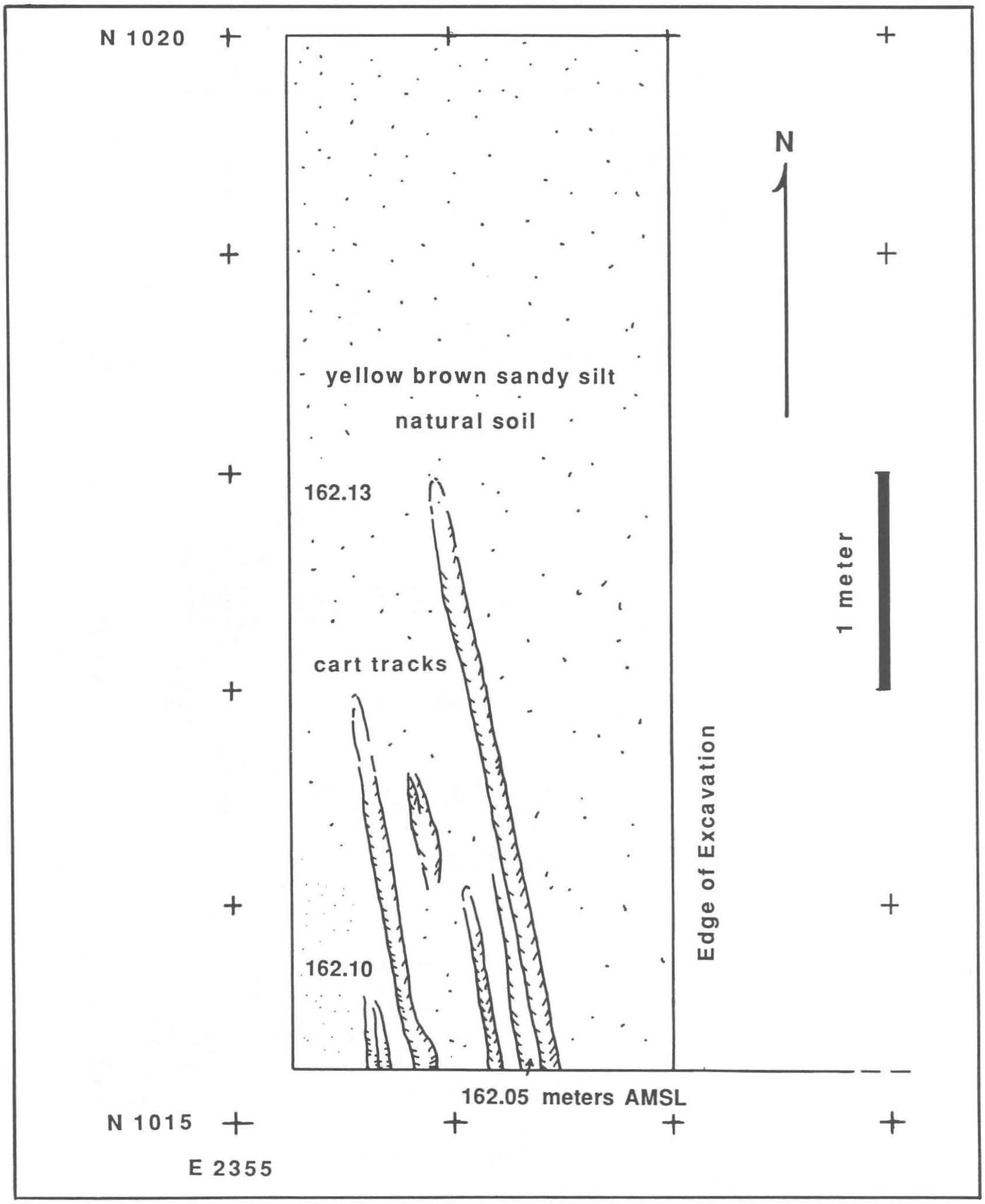

Figure 13.41: Harappa 1990: Mound E, southern slope, area C: plan of lowest street level (Period 2).

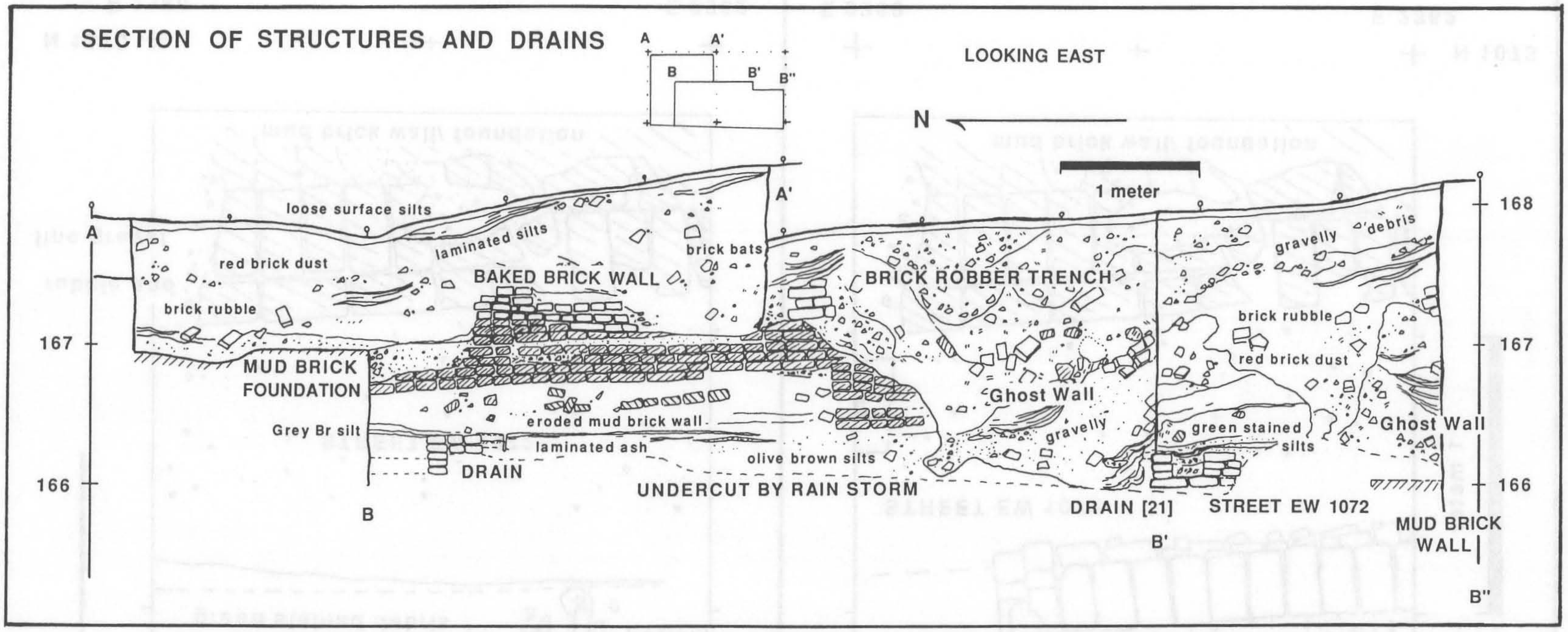

Figure 13.42: Harappa 1990: Mound E, southern slope, area A: section of Harappan phase structures and drains, facing east.

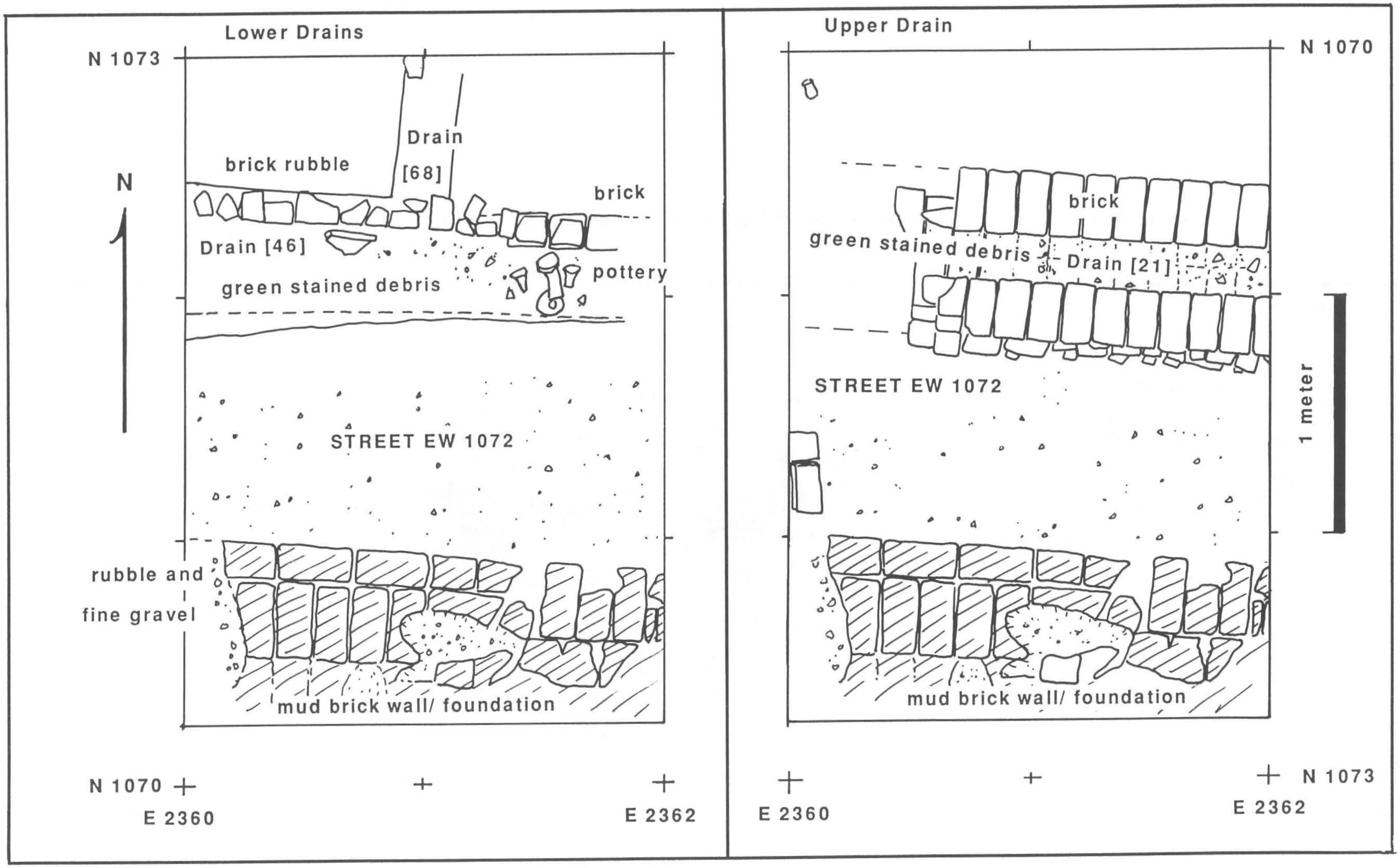

Figure 13.43: Harappa 1990: Mound E, southern slope, area A: plan views of drains.

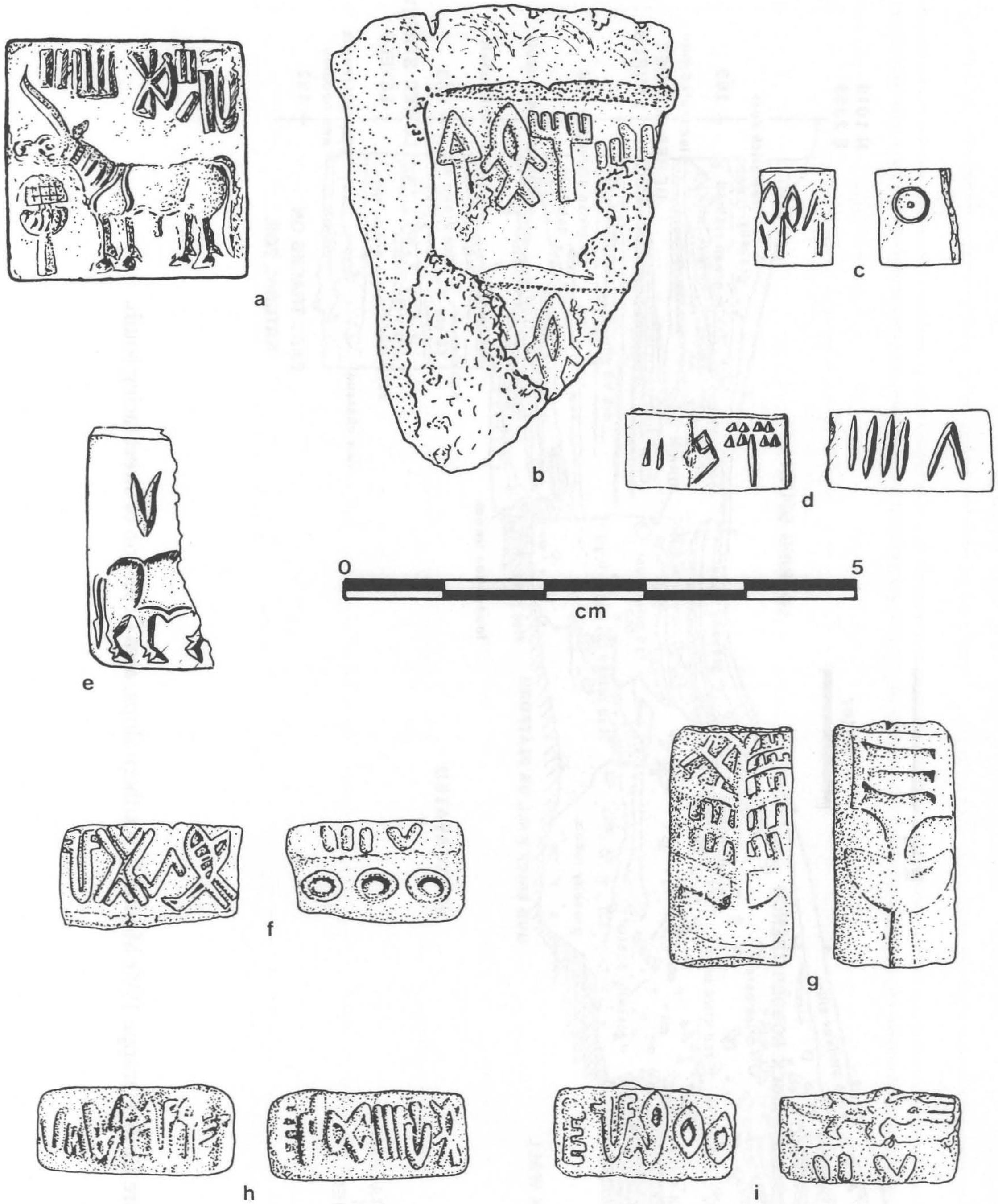

Figure 13.44: Harappa 1990: Objects with script from Mound E, southern slope. (a) Intaglio steatite seal (H90-1618/3250-1) from upper street levels, area C, Period 3B/C. (b) Terracotta sealing (H90-1686/3043-35) from upper street levels, area C, Period 3B/C. (c) Inscribed steatite token fragment (H90-1619/3154-1) from under drain #[14] next to upper street levels, area C. (d) Inscribed steatite token (H90-1688/3056-18) from upper street levels, area C. (e) Intaglio steatite seal fragment (H90-1600/3166-1) from lower street levels, area C, Period 3A. (f) Three sided faience token (H90-1628/3124-4) from houses next to street, area A, Period 3B. (g) Faience token (H90-1687/3103-1) from surface above street, area A, Period 3B/C. (h) Faience token (H90-1601/3094-1) from houses next to street, area B, Period 3B. (i) Three sided faience token (H90-1591/3033-1) from houses next to street, area B, Period 3B.

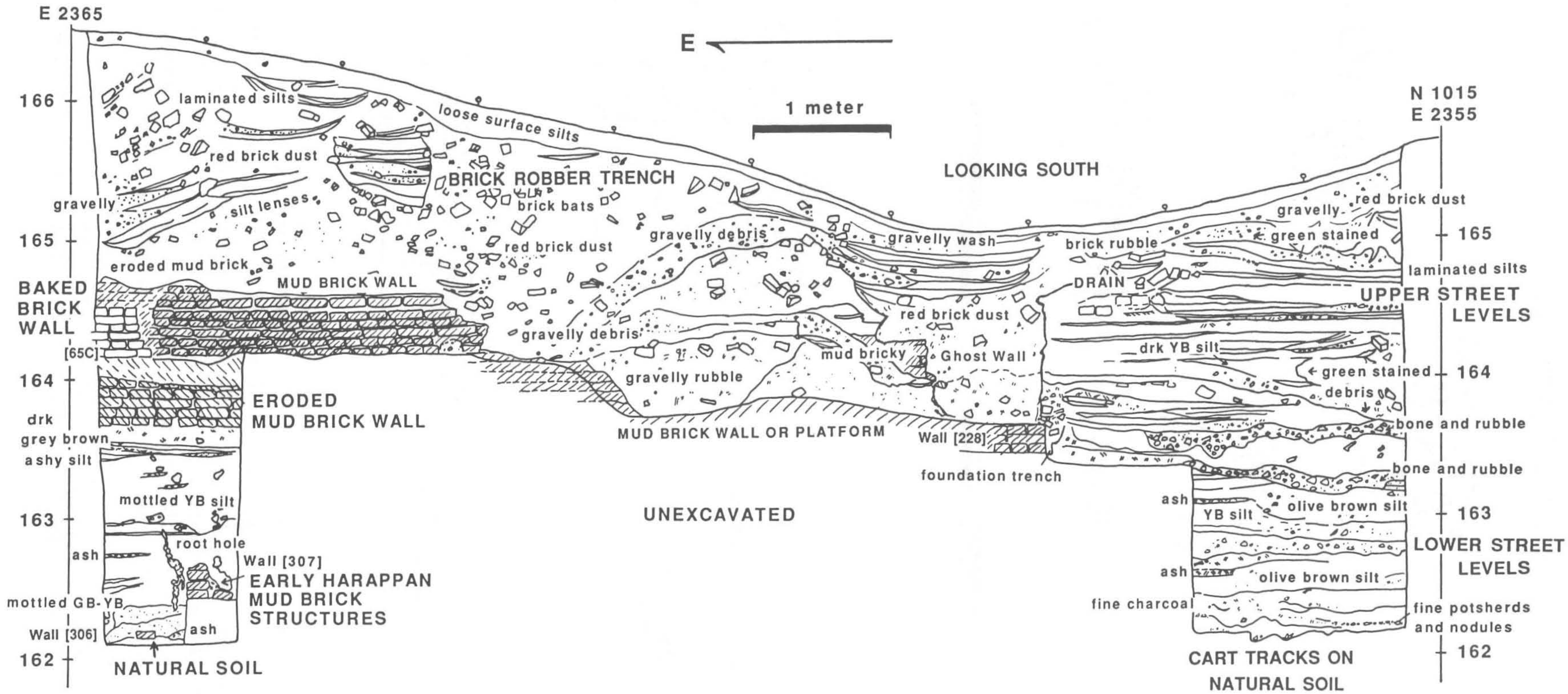

Figure 13.45: Harappa 1990: Mound E, southern slope, area C: section of street facing south.

suggests that the structure was probably abandoned and used as a dump for some time before it was leveled off and rebuilt.

The final phase of building involved the construction of a massive mud-brick foundation platform (Feature #[28]) upon which was constructed a house made with baked bricks (Figure 13.40). Due to brick robbing, the baked brick walls of the latest structures are missing. However, the mud-brick foundation platforms and interior household deposits were undisturbed.

Inside this house structure, Room 1 lies adjacent to the street and may have been a covered courtyard with a wooden superstructure or roof. Three distinct post holes were found along an east-west line in the center of the room. A small kiln or oven (Feature #[36/46]) and several pits filled with domestic debris were excavated in this room.

To the east of Room 1, divided by baked brick walls, are what appear to be two interior rooms (Rooms 2 and 3) of the house built almost directly above and aligned with earlier mud-brick walls. Although the baked brick walls had been robbed, a paving made from broken brick bats sealed the floors of these two rooms, which consisted of hard-packed conglomerate of pottery, bone, charcoal, and nodules. The artifacts found in the debris within these rooms included pottery, stone tools, beads, terra-cotta figurines, and toys. Most important are nine objects with Harappan script (Figure 13.46c-k). These objects came from various levels of floor debris and fill within the two rooms.

Combined with the two objects found in Room 1 (Figure 13.46a-b), a total of eleven objects with Harappan script were found in the three rooms of this house. These include two steatite intaglio seals (one complete and one broken) with the common unicorn animal motif and short inscription; three identical rectangular molded faience tokens with script on both faces; one molded rectangular token with script only on one face; one flat triangular token and one flat lunate token with script on both faces. In addition to the faience tokens, two inscribed and fired steatite tokens and one terra-cotta cone with a crudely incised inscription were also found (Figure 13.46).

Throughout all of the levels of the street and the house, large quantities of faunal and floral remains were recovered. These samples provide a relatively continuous record of the types of animals and plants being used and discarded in this area of the city. [*See Chapters 7 and 8 in this volume.*]

In Area D, south of the house structure in Area C, a 3 × 2 m pit was excavated along the alignment of the street NS2355 (Figure 13.39). In this area, hard-packed layers of horizontally deposited brick bats and sherds covered a thick accumulation of green stained refuse in what may have been a street. These deposits correspond to the street levels found to the north.

In Area E, south of Area D and also along the alignment of street NS2355, excavations in a 5 × 2 meter unit exposed an east-west aligned baked brick drain (Feature #[244]) (Figures 13.39 and 13.47). Although the exposure was small, the drain (#[244]) clearly slopes from east to west. It cuts across the projected path of the north-south street NS2355 and may represent an east-west street. Further excavation is needed to clarify this question.

In Area F, south along the line of the street NS2355, a test pit revealed the presence of two superimposed massive mud-brick walls (Features #[30] and #[40]) that conform to the curvature of the southern edge of Mound E (Figures 13.39 and 13.47). This initial test trench (2 × 3 meters) was excavated to natural soil and showed that the construction of the earliest wall (Feature #[40]) occurred on a gently undulating natural surface. Instead of digging a level foundation trench, the Harappan builders appear to have stepped the lowest courses of bricks to accommodate the irregular surface. In this initial exposure, the wall #[40] is oriented at approximately 28 degrees north of east (Figure 13.48), and the bricks (10 × 20 × 40 cm) were made of clean, grey-brown clay containing some *kankar* nodules. The mortar contained some Period 3 potsherds. Other pottery found beneath the wall confirms that wall #[40] was built during Period 3. It is not possible to determine how high this wall stood, but it appears to have been a free standing wall.

Following considerable erosion of the early wall, the second wall (Feature #[30]) was constructed almost one meter inside the line of wall #[40] and oriented c. 18 degrees north of east in this exposure (Figures 13.48 and 13.49). Again the bricks were made of grey-brown clay with *kankar* nodules and the mortar contained occasional potsherds of Period 3.

Numerous extensions and exploratory trenches were made to understand the extent of wall #[30] (Figure 13.47). The result of these excavations revealed that a massive mud-brick wall extended in an arc for over 73 meters along the southern edge of the mound. A break in the wall appears to have been an entrance or gateway (Feature #[84]), and there is evidence for an earlier entrance as well (Feature #[85]). Two distinct sets of street levels (street NS 2338) are visible passing through the entrance or gateway.

The similarities in mud-brick color and composition suggest that wall #[30] andthe gateway were built in one major episode. The original width of wall #[30] ranges from 5.4 to 6.5 m in two areas, but at the gateway it is 8.5 meters wide. Later repairs (Figure 13.47) and additions had been made on the exterior

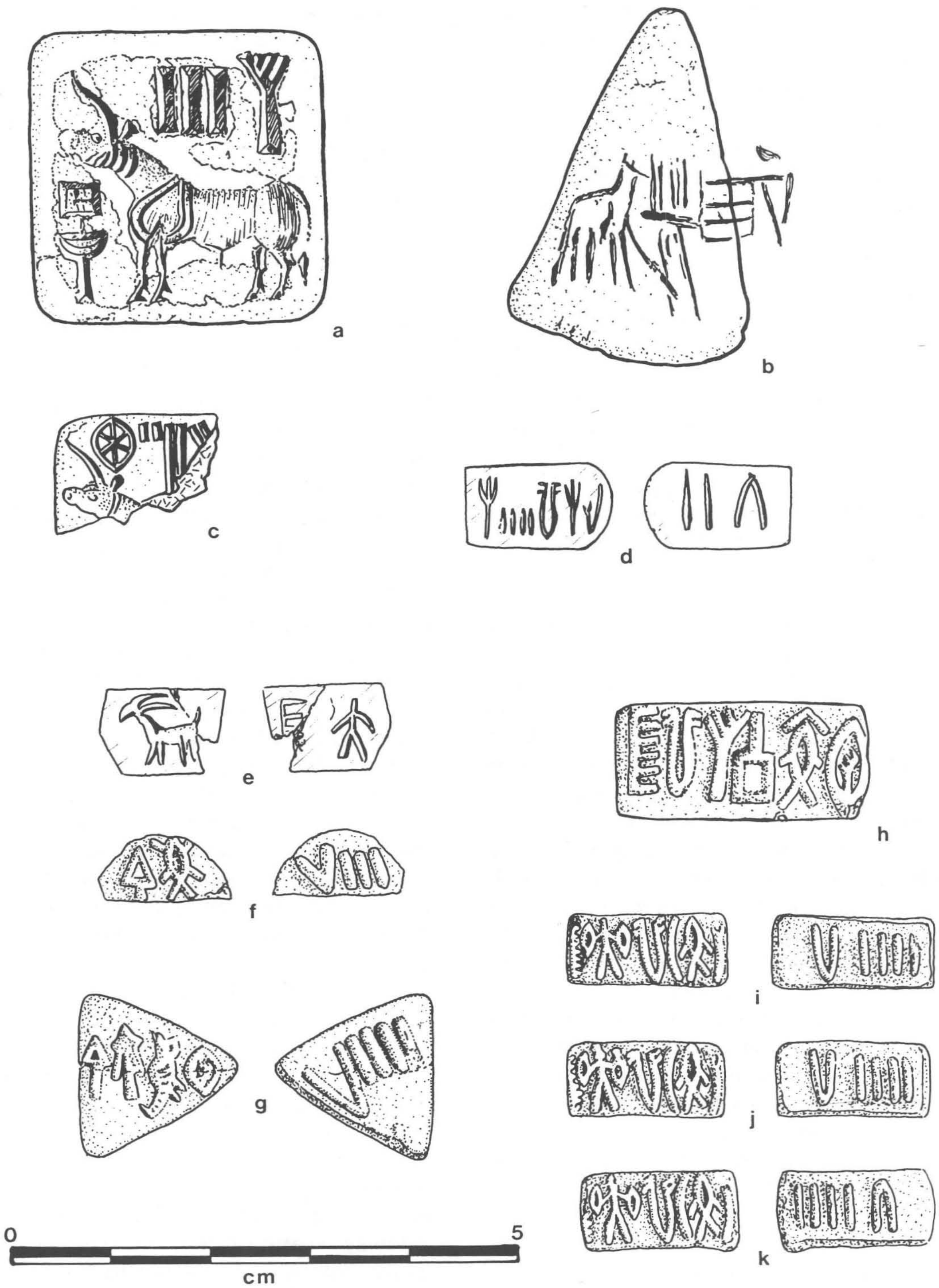

Figure 13.46: Harappa 1990: Objects with script from Mound E, southern slope, area C. (a) Intaglio steatite seal (H90-1578/3038-1) from pit in room 1 (see Figure 13.40). (b) Inscribed terracotta cone (H90-1672/3063-5) from pit in room 1 (see Figure 13.40). (c) Intaglio steatite seal fragment (H90-1594/3064-10) from room 2. (d) Inscribed steatite token (H90-1690/3064-11) from room 2. (e) H90-1712/3255-4 Inscribed steatite token from room 3. (f) Faience token (H90-1627/3255-1) from room 3. (g) Faience token (H90-1597/3157-1) from room 3. (h) Faience token (H90-1592/3042-4) from room 3. (i) Faience token (H90-1595/3155-3) from room 3. (j) Faience token (H90-1596/3155-4) from room 3. (k) Faience token (H90-1593/3064-9) from room 3.

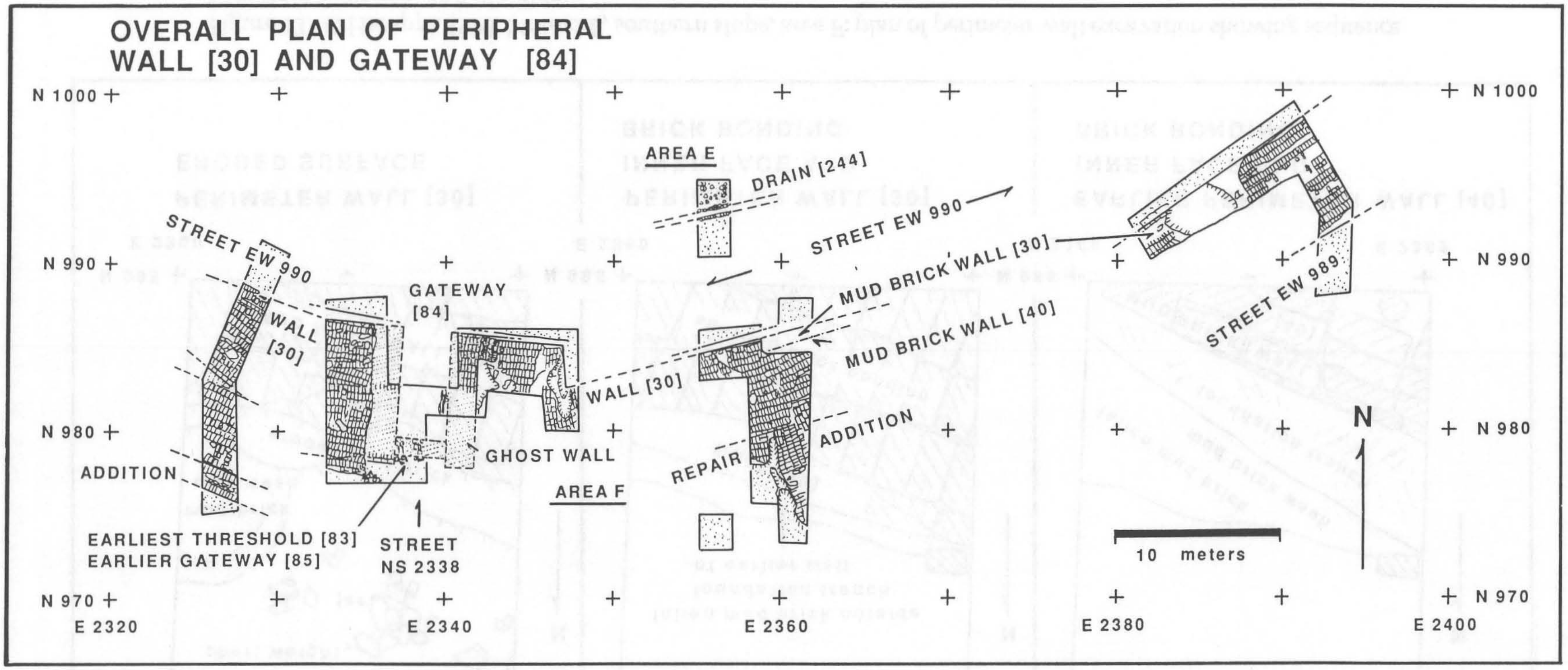

Figure 13.47: Harappa 1990: Mound E, southern slope, area F: overall plan of peripheral wall and gateway.

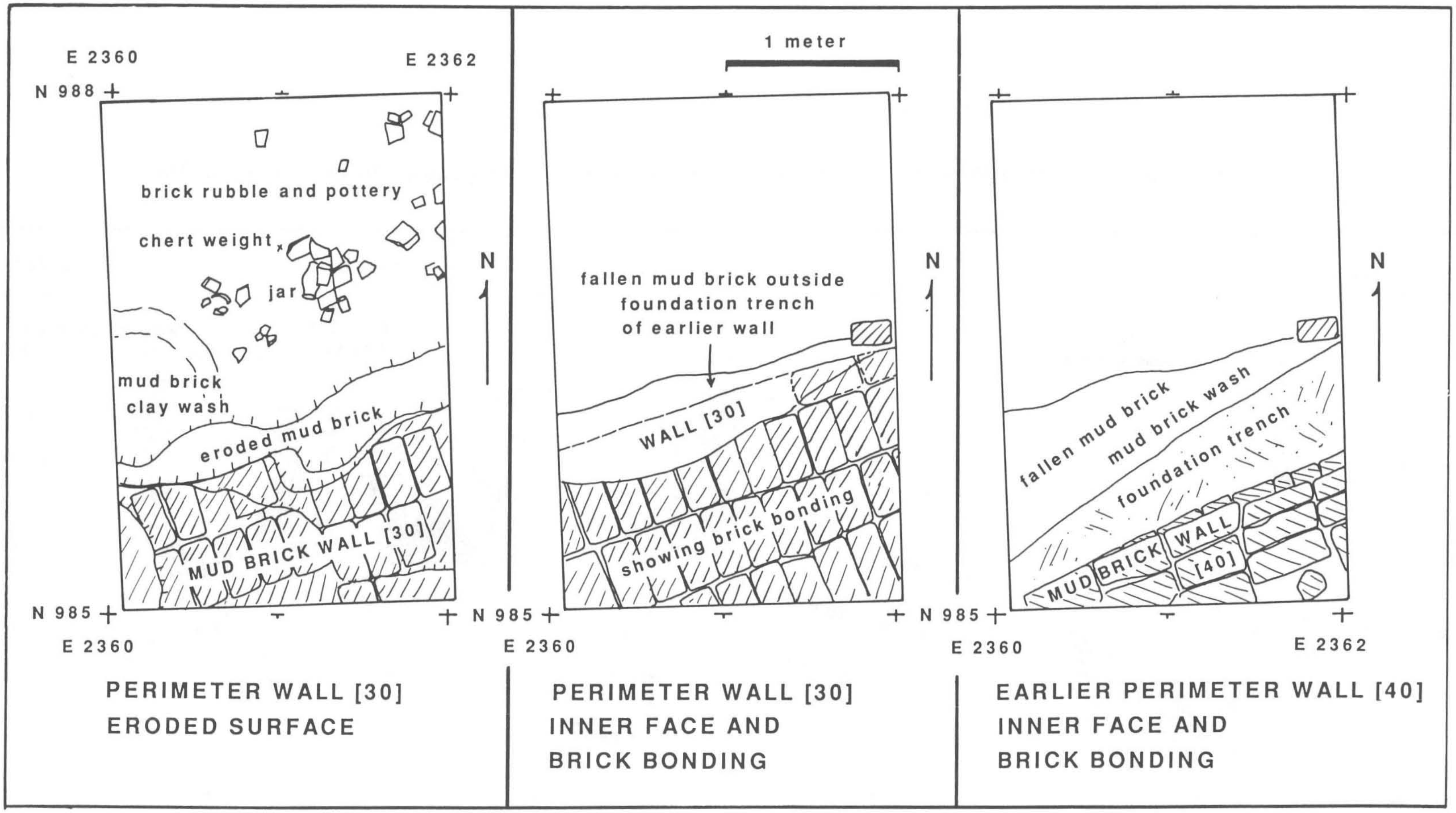

Figure 13.48: Harappa 1990: Mound E, southern slope, area F: plan of perimeter wall excavation showing sequence of building, erosion, and rebuilding.

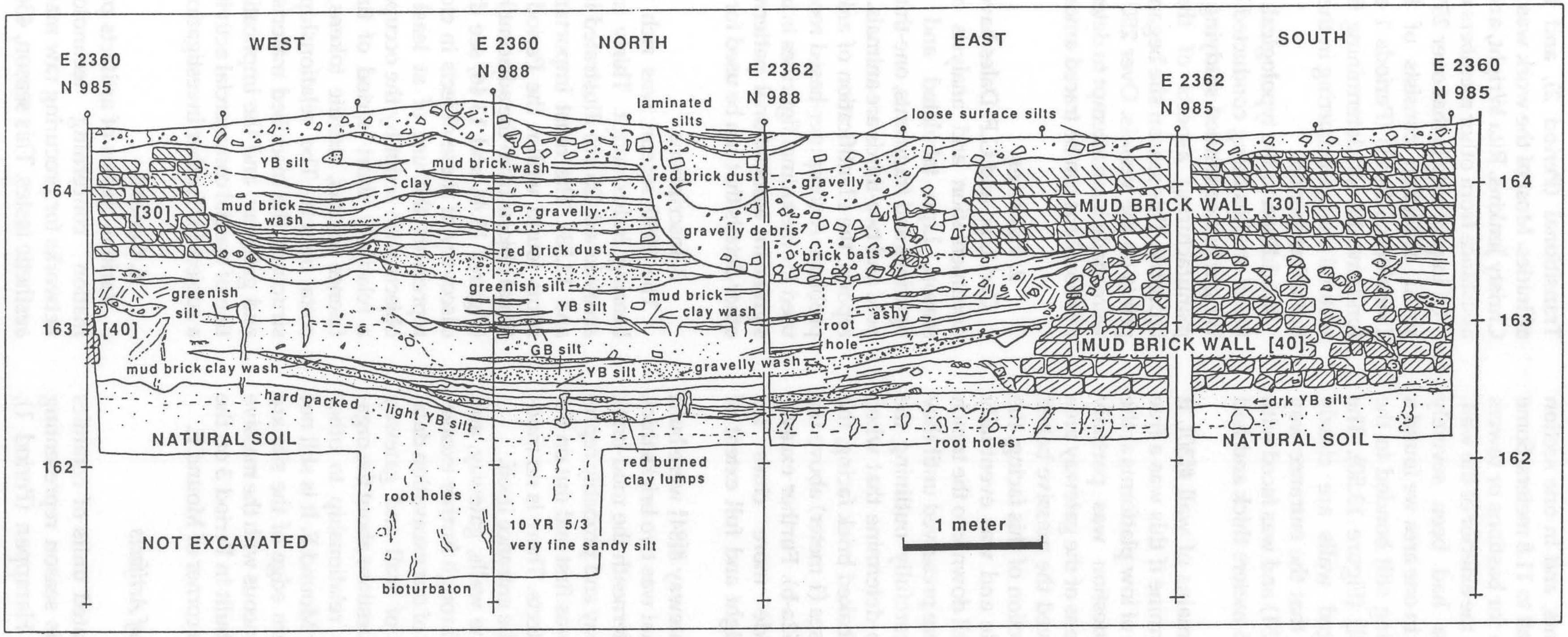

Figure 13.49: Harappa 1990: Mound E, southern slope, area F: section showing sequence of building, erosion, and rebuilding of perimeter walls (see Figure 13.48).Facing west, north, east, and south from left to right.

face of the wall at various points, and in one section they expand the width of the wall to 11.8 meters. Some of the additions may have been for bastions or towers or simply for wide platforms on the exterior of the wall.

Although the gateway area had been severely disturbed after it fell out of use, in one area we found a portion of the baked brick facing still bonded to the mud-brick wall (Feature #[30]) (Figure 13.50). The outlines of the brick-scavenged walls are clearly visible in section and indicate that the entrance way was 2.8 meters wide (Figure 13.51) and was faced with baked brick walls that were 1.6 meters thick and had one meter deep foundations.

In excavating the eroded remains of wall #[30], it was important to try and determine if this was a free standing wall or simply a series of low platforms at the edge of the mound. This question was partially answered in two different sections of the gateway area where brick robbers had removed the massive baked brick facing. Without the protection of this facing, the mud-brick wall began to erode and was eventually undercut. Portions of the wall fell down into the trench left by the brick robbers and were preserved until they were excavated in 1990. By carefully outlining the fallen bricks it was possible to determine that when the brick robbers removed the baked brick facing, the mud-brick wall stood ten courses (1 meter) above the level of wall #[30] (Figure 13.52a-b). Further excavations will hopefully provide more clues for understanding the original height and full extent of this massive wall.

The baked brick facings of gateway #[84] were built on top of a mud-brick paving that was two bricks thick (20 cms). This paving runs underneath the mud-brick walls on both sides of the gateway and probably represents the plan of the wall that was first laid out on the ground by the Harappan architects. There is no mud-brick paving extending across the entrance itself.

Many questions regarding the walls, gateway, and streets remain to be answered through further excavation and more detailed analysis of our excavation data. The discovery of two phases of wall and gateway construction raises numerous questions about the organization of Mound E and its relationship to other mounds, such as Mound AB or Mound F. It is still not clear if the walls at the southern edge of the site are contiguous and/or contemporaneous with the massive brick revetment wall that was built in Period 3 on the western edge and northwestern corner of Mound E.

B. *Analyses of Specific Classes of Artifacts*

1. Pottery

Approximately 1,000 excavated units of ceramics were sorted and tabulated this season representing over 400,000 sherds of Early Harappan (Period 1), Transitional (Period 2), and Harappan (Period 3) affinities. Most of the work was accomplished by Paul Christy Jenkins, Rita Wright, and Chris Kostman with assistance from other members of the team.

Of importance is that over 25% of the 1990 season's sherd collection consists of Early Harappan and Transitional forms (Periods 1 and 2). Their study is fundamental for determining the degree and rate of cultural change occurring in the transformation to the full urban period.

In addition to the typological, stylistic, and distributional studies being conducted by Jenkins and Dales, Wright has continued studying the technological and manufacturing aspects of the Harappan ceramic industry. This season she began an analysis of fingerprints on the vessels. Over 250 impressions of prints were made in an attempt to determine whether genetic relationships can be traced among the ancient potters.

2. Figurines

Carl Lipo and G.F. Dales have been working on the documentation and analysis of the figurines. This season, Lipo tabulated and described some 190 figurines and fragments, one-third of which are anthropoid and two-thirds are animals. As described in earlier reports, the identification of animal species is a major problem. A computer-based recording system is being used for the animal figurines in an attempt to recognize significant associational patterns of facial, horn, and other details that can be used for species identification.

3. Inscriptions

The 1990 season was rich in finds of materials bearing Indus script. Thirty inscribed objects were accessioned (25 are illustrated in Figures 13.44, 13.46, and 13.53). The most important of these are the 11 items found within the Period 3 house and 7 additional objects from the adjacent houses and street areas (Figures 13.44 and 13.46; see discussion above). The discovery of these objects in closely associated strata represents the use of at least four major types of objects with script by the occupants of the house over a relatively short period of time: true stamp seals, faience tokens, steatite tokens, and inscribed terracotta objects. The relationship between the house structure, the inscribed materials, and the large wall and gateway, and the implications for the identification of special commercial activities carried out here, is a subject for further investigation.

4. General

Various classes of artifacts provide valuable information concerning technology, trade/exchange networks for procuring raw materials, and changes in aesthetic tastes. This season, 436 objects, or groups of

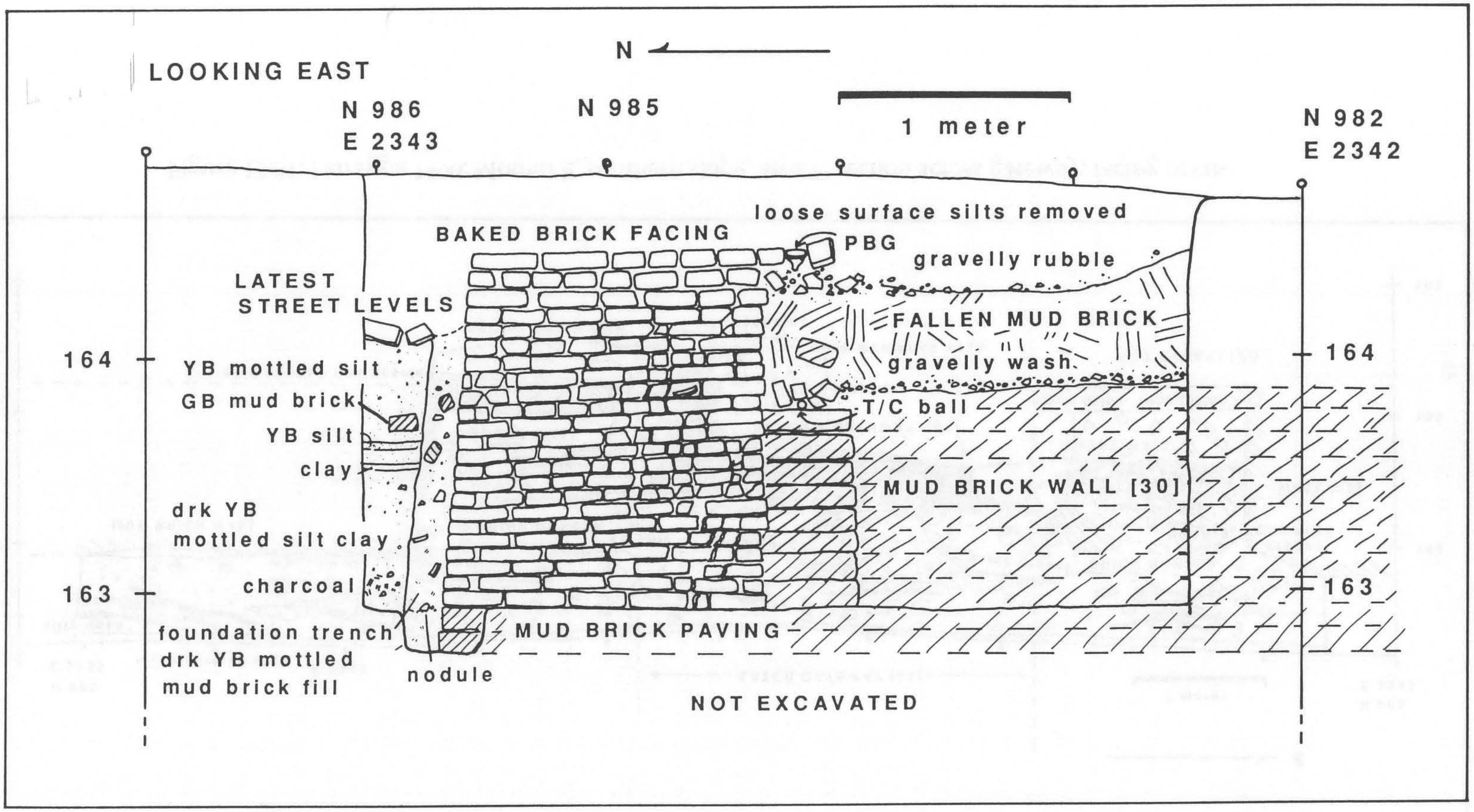

Figure 13.50: Harappa 1990: Mound E, southern slope, area F: section of brick facing and foundation of perimeter wall at east edge of gateway, facing east.

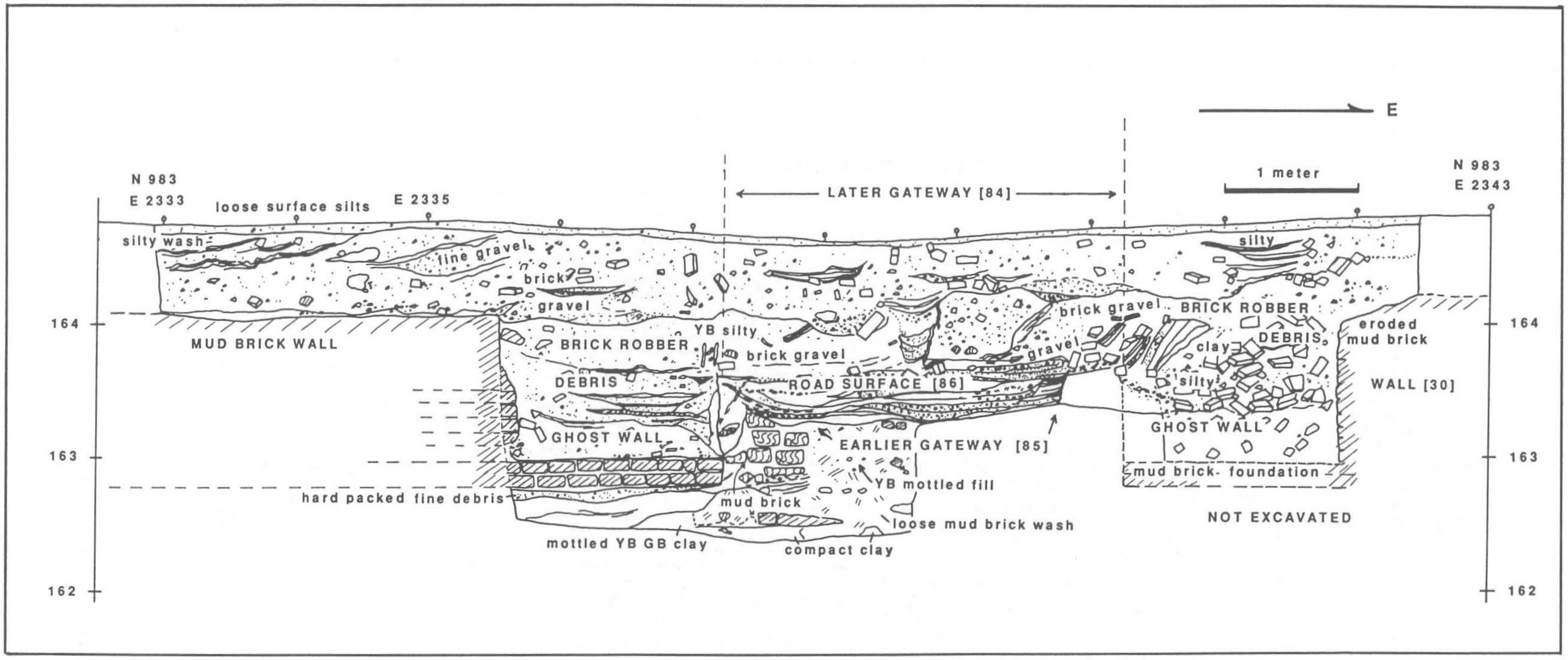

Figure 13.51: Harappa 1990: Mound E, southern slope, area F: section across gateway, facing north.

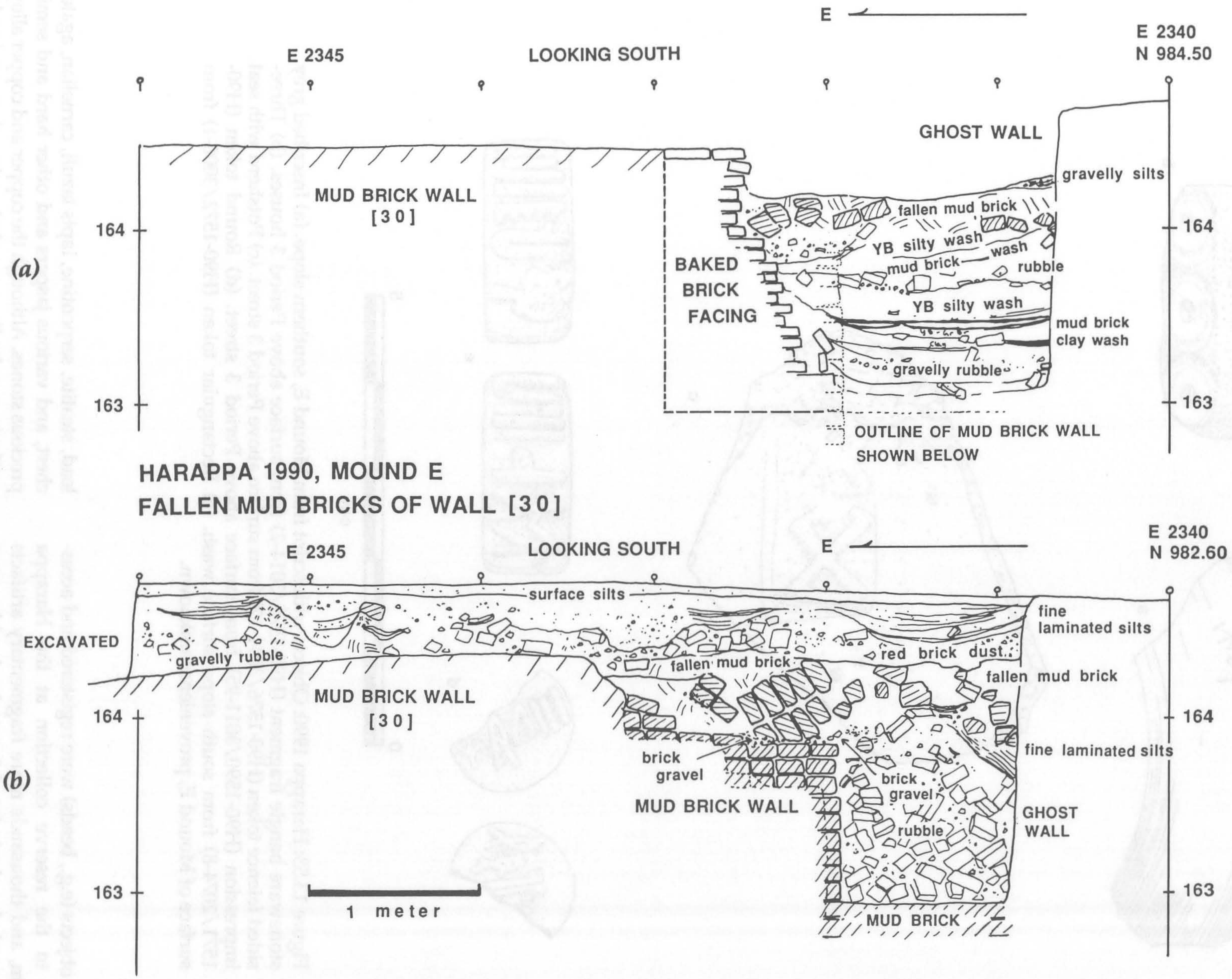

Figure 13.52: Harappa 1990: Mound E, southern slope, area F: sections showing fallen mud-bricks of perimeter wall, facing south.

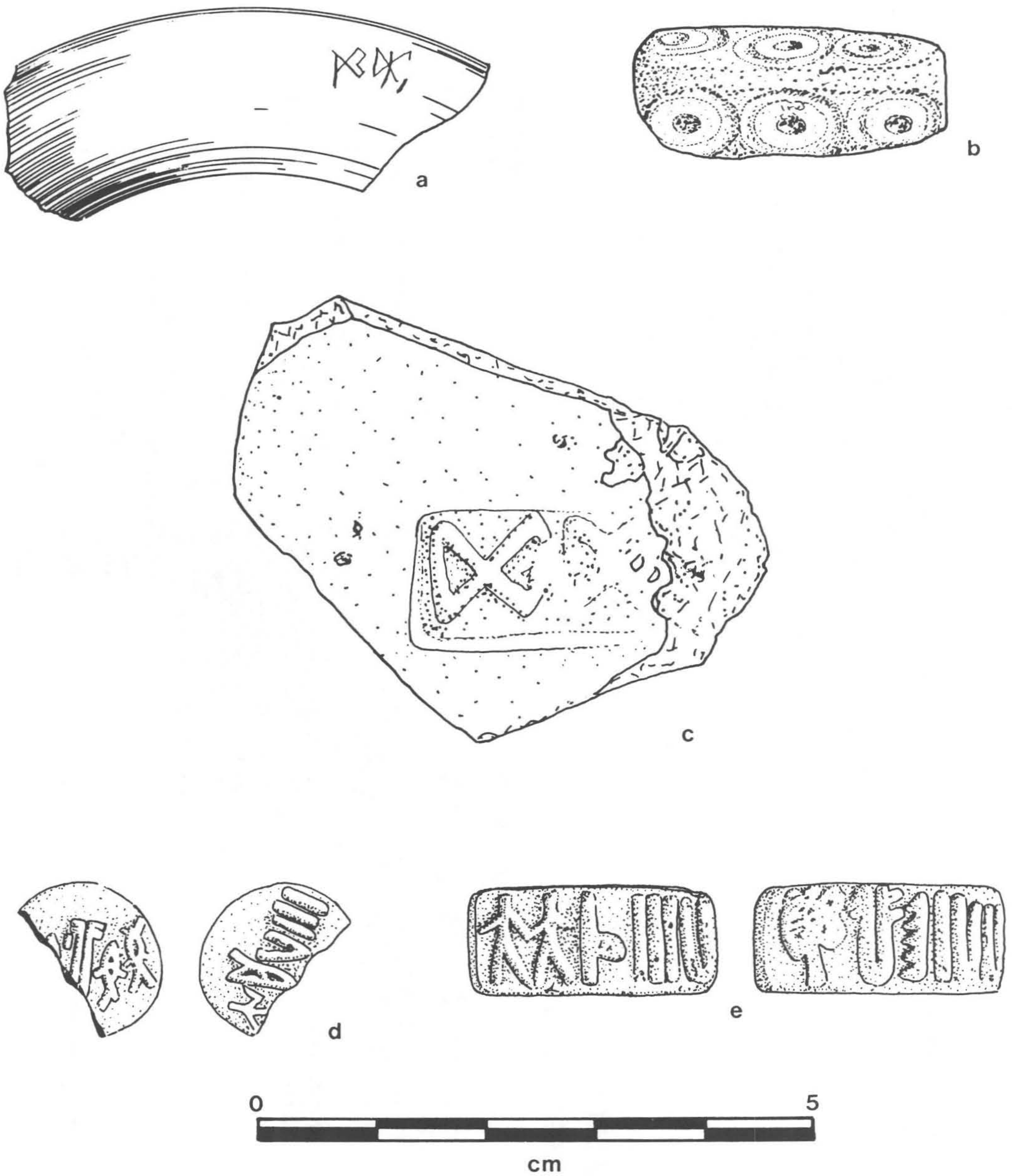

Figure 13.53: Harappa 1990: Objects with script from Mound E, southern slope. (a) Inscribed grey stoneware bangle fragment (H90-1575/3014-2) from surface above Period 3 houses. (b) Three-sided faience token (H90-1576/3011-17) from surface above Period 3 street. (c) Potsherd with seal impression (H90-1590/3011-95) from surface above Period 3 street. (d) Round token (H90-1571/2074-8) from south slope surface wash. (e) Rectangular token (H90-1572/3000-1) from surface of Mound E, provenience unknown.

similar objects (e.g., beads) were registered and accessioned to the reserve collection at the Harappa Museum, and thousands more fragmentary artifacts were recorded and tabulated for study. A wide range of materials is represented including terra cotta, faience, stoneware, shell, bone, ivory, gold, copper, lead, steatite, serpentine, lapis lazuli, carnelian, agate, chert, and various jaspers and other hard and semi-precious stones. Although the copper and copper alloy artifacts are badly corroded, winged arrowheads, blades, chisels, balance pans, and various pins and other ornaments were identified.

Also continued in the 1990 season were the technological experiments concerned with the forming and firing of pottery, faience, stoneware bangles, lithic implements, and beads.

C. *Palaeoenvironmental Studies*

1. Palaeozoological Studies [*See Chapters 7 and 8 in this volume.*]

Richard Meadow continued his study of the animal remains, assisted by Tonya Largy of Harvard University. Preliminary study this season of the remains from Period 2 and Period 3 street deposits from the southern edge of Mound E confirms the presence of a wide range of wild fauna although the assemblages are dominated by bones of cattle, water buffalo, sheep, and goats. The cattle in particular show a range of sizes from relatively small cows to enormous draft bulls. As in material from previous seasons, sheep bones are much more common than those of goat, and some of the sheep were very large, suggesting special breeding practices. Water buffalo remains are rare but there is admittedly some difficulty in distinguishing the bones of water buffalo and cattle.

In addition to the larger animals, remains of fish, small mammals, birds, rodents, reptiles, and even crab claws were recovered as a by-product of the flotation process used to recover the botanical remains.

To increase the accuracy of making identifications of the larger animals, the collection of modern bones from the Harappa city 'bone pits,' started in 1989, was continued.

2. Palaeobotanical Studies

The collection of plant remains was conducted by Heather Miller. More than 2,750 liters of sediments from more than 185 excavated units were processed for carbonized plant remains using the project's flotation machine. A large quantity of ancient plant remains was recovered from domestic and debris contexts of all phases of occupation along the southern slope of Mound E. Important will be the comparison of remains from the pre-urban (Periods 1 and 2) and the full urban period (3).

D. *Conservation*

The field laboratory this season was under the supervision of Harriett Beaubien of the Smithsonian's Conservation Analytical Laboratory. She was assisted by Julie Lauffenberger of the same institution. As in previous seasons, most of the conservation problems resulted from damage to the artifacts caused by the high salinity of the soil. Desalination procedures continued with emphasis on artifacts selected for accessioning and those kept for study collections. Repair and restoration work was performed on all accessioned objects requiring such attention.

As for conservation efforts on the site, all drains, water diversions, and other efforts to protect the excavations from erosion were checked and repaired where necessary. Mud-brick and plaster walls were constructed around the kilns that were excavated at the northwestern corner of Mound E during the 1989 season. The excavations of the massive mud-brick wall system and entrance way discovered this season along the southern edge of Mound E were covered with fine river sand and then refilled with soil to protect them for future excavations and study. A small trench was also dug across one area of the Old Police Station mound, at the eastern extremity of Mound E, in order to discourage the use of the mound as a roadway by the local Harappa buses. This motorized activity during the past few years has been destructive to the mound and has induced undue erosion.

E. *Training Program*

1. Pakistani Graduate Students

The intended field training program for graduate students from the University of the Punjab and Shah Abdul Latif University (Khairpur) was cancelled due to unforeseen circumstances.

2. Illustrators

Significant progress was made in the training of archaeological illustrators this season. Shokat Ali Shad and Rifa'at Saif Dar of Punjab University have become quite proficient at illustrating pottery and small finds.

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